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The New W. U. 301
Computer Switching System

In keeping with its policy of providing the most modern and efficient communications systems for Private Wire and Government applications, the Western Union Telegraph Company has developed a new data and telegraph switching system designated the "New Western Union 301 Computer Switching System." This system has been designed to provide a smooth and orderly change over from the electro-mechanical systems of yesterday to the computerized, stored-program, solid state systems of the present and future.

The 301 Computer Switching System was designed by Western Union to meet the needs of both small and large store-and-forward communication systems. It offers numerous new services for digital transmission networks that far surpass the capabilities of existing electro-mechanical telegraph switching systems at a cost below that of the equivalent electro-mechanical switching system.

This system is specifically intended for on-line, real-time, digital, store-and-forward communication applications. In addition to its message switching functions the system can also perform data processing functions simultaneously, but the amount of data processing depends upon the message load. A variety of peripheral equipment such as magnetic tape units, magnetic drums, high speed printers, high speed paper tape readers, high speed paper tape punches and high speed card equipment can be connected to the system at the Computer Center depending on the needs of each customer or patron.

Communication Termination Capability

The new Western Union 301 Computer Switching System consists of specially designed communication termination equipment and a commercial stored-program computer.

The system is flexible enough to terminate from 2 to approximately 110 digital communication circuits depending on the speed and types of circuits used. Circuits terminated in the 301 System may use any code comprised of up to 8 intelligence bits per character and may operate at speeds from 45 bits per second to 15,000 characters per second.

Store-and-Forward Operation

Store-and-forward operation is defined as the process by which a message is first received and stored at a switching center before being forwarded to its intended destination. In some systems the processor must receive the entire message before forwarding it; and in other systems a partial message is forwarded as soon as only the header portion or the address of the message is received. The latter method is usually employed only in those systems where all subscriber equipment operates at the same speed (e.g. 100 words per minute) and no error detecting techniques are utilized. It is normally not employed when mixed speed terminal equipment is used, because a message sent from a low speed station to a high speed station would then have an effective transmission rate on the high speed circuit which was approximately the same as that of the low speed circuit.
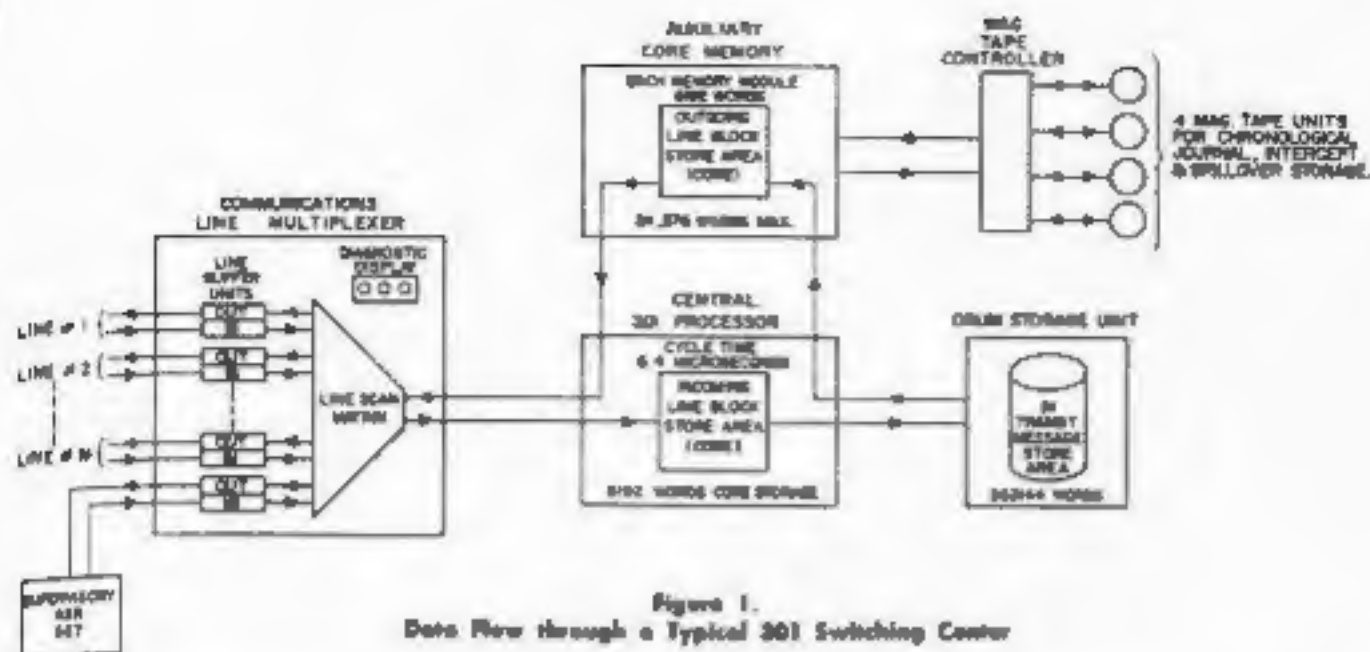
Figure 1.
Data Flow through a Typical 301 Switching Center

General System Operation

Figure 1 shows the equipment configuration and information flow in a typical 301 store-and-forward Switching Center. Characters are received at the Center in serial fashion, bit-by-bit and character-by-character, on the input side of the line buffers of the Multiplexer. When a whole character has been received, it is forwarded through the Line Scan Matrix to the Central Processor (Computer). Characters are assembled in the processor in magnetic core memory in an Incoming Line Block Store Area that is assigned to each incoming line. When this area is filled, the entire block is transferred to the magnetic drum to await processing. When the end-of-message code is received, the last incoming line block is written on the magnetic drum. The processor then examines the message header and determines the proper routing for the message. If the Outgoing Block Area, for the outgoing circuit to which the message is destined, is available, the first block of the message will be transferred from the magnetic drum to the auxiliary core memory in the processor. One character at a time will then be removed from the Outgoing Line Block Store Area and sent through the Line Scan Matrix, to the appropriate output line buffer unit in the Multiplexer. The character is then shifted, serially, out of the line buffer at the appropriate bit rate of the communication circuit. Each time the Output Line Block Store Area is emptied, it will be refilled by moving the next block of the message from the magnetic drum into core memory. The process continues until the entire message is delivered.

Magnetic tape is used as bulk storage media in switching applications. A Spillover Storage Tape unit is used in the event the drum should become filled. An Intercept Storage Tape unit is assigned for messages that are held for prolonged periods of time. A Journal Tape unit is used to keep a record of all messages that have passed through the system. A more detailed description of the tape functions will follow later in this article.

Message Format

In order to perform automatic message switching functions, the information entered into the system must be prepared according to a prescribed format.

The format is quite flexible and may meet the needs of each individual customer. A typical message format should contain the following:

a) Start-of-Message Code
b) Origin Indicator and Sequence Number
c) Start-of-Routing Code
d) Routing Indicator(s)-each may have 1 to 7 alpha-numeric characters
e) End-of-Routing Code
f) Text of Message
g) End-of-Message Code

SP FIGS 26 SP 966 – 11 SP 3291 CR LF
I AND 5 3   2   3   4   2   7   6

2a.　　　TEXT OF MESSAGE　FIGS H
　　　　　　　　　　　　　　9

ZCZC SP ME SP FIGS 101 CR LF
1   2   4   2   7   6

2b.　　　LTRS YOU SP HIM SP CHARLES SP A CR LF
　　　　　　　3   2   3   2   3   2 3   2

FIGS 012637 SP LTRS END CR LF
5   2   6

TEXT OF MESSAGE　NNNN
　　　　　　　　　　9

Legend:

SP = Telegraphic Character "SPACE"

CR = Telegraphic Character "Carriage Return"

LF = Telegraphic Character "Line Feed"

FIGS = Telegraphic Character "Figures Shift"

LTRS = Telegraphic Character "Letters Shift"

(1) Start of Message Code
(2) Information Separator
(3) Destination Address (Routing Indicator)
(4) Originator Identification Code
(5) Telex Station Number
(6) End of Routing Code
(7) Originator's Message Sequence Number
(8) Start of Routing Code
(9) End of Message Code

Figure 2. Two Sample Message Formats (a) & (b)

Computer Systems vs. Electro-mechanical Systems

Automatic electro-mechanical tele-graph switching centers, of the store-and-forward variety, usually have a receiving position associated with each incoming line where incoming messages are re-corded on perforated paper tape. The tape is then transmitted, cross-office, via interconnecting circuits to a sending position. Here, the message is again re-corded on perforated paper tape, for transmission over the sending line to the addressee.[1] In contrast, the computer-type store-and-forward switching center uses one common storage area (magnetic drum, magnetic tape, or magnetic disc) for all incoming messages and all mes-sages awaiting outgoing delivery. The tre-mendously high information transfer rate to and from the computer (up to 70,000 characters per second in the 301 System) makes it possible to use the common stor-age area technique. In the older electro-

mechanical switching centers, cross office speed was limited to approximately 20 characters per second on each cross office circuit.

Another limitation of the electro-mechanical type switching center is its inability to terminate a variety of outstation terminals. This type of switching center usually restricts all outstations to the use of one code and to one of a few standard telegraph speeds (60-, 75-, or 100 words per minute). The primary reason for this is the high cost of providing the required speed and code conversion equipment at the electro-mechanical switching center on a per line basis. High speed computer operation allows one common code and/or speed conversion program to be shared by many lines, thus holding the per-line cost to a minimum for these features.

An outstanding feature of the computer type switching center is its ability to perform new and varied system functions by merely loading in new programs—no hardware changes are required.

301 Processor

The Western Union 301 Processor, shown in Figure 3, is a medium size computer equipped with an operator's control panel, a basic memory of 8,192 computer words of magnetic core storage, a high-speed paper tape reader and a high speed, paper tape punch. Each computer word consists of 12 binary bits and is used as a storage media for computer instructions, message text and data. The computer has two high speed input-output channels plus an internal and external interrupt capability. The basic memory can be expanded by means of additional
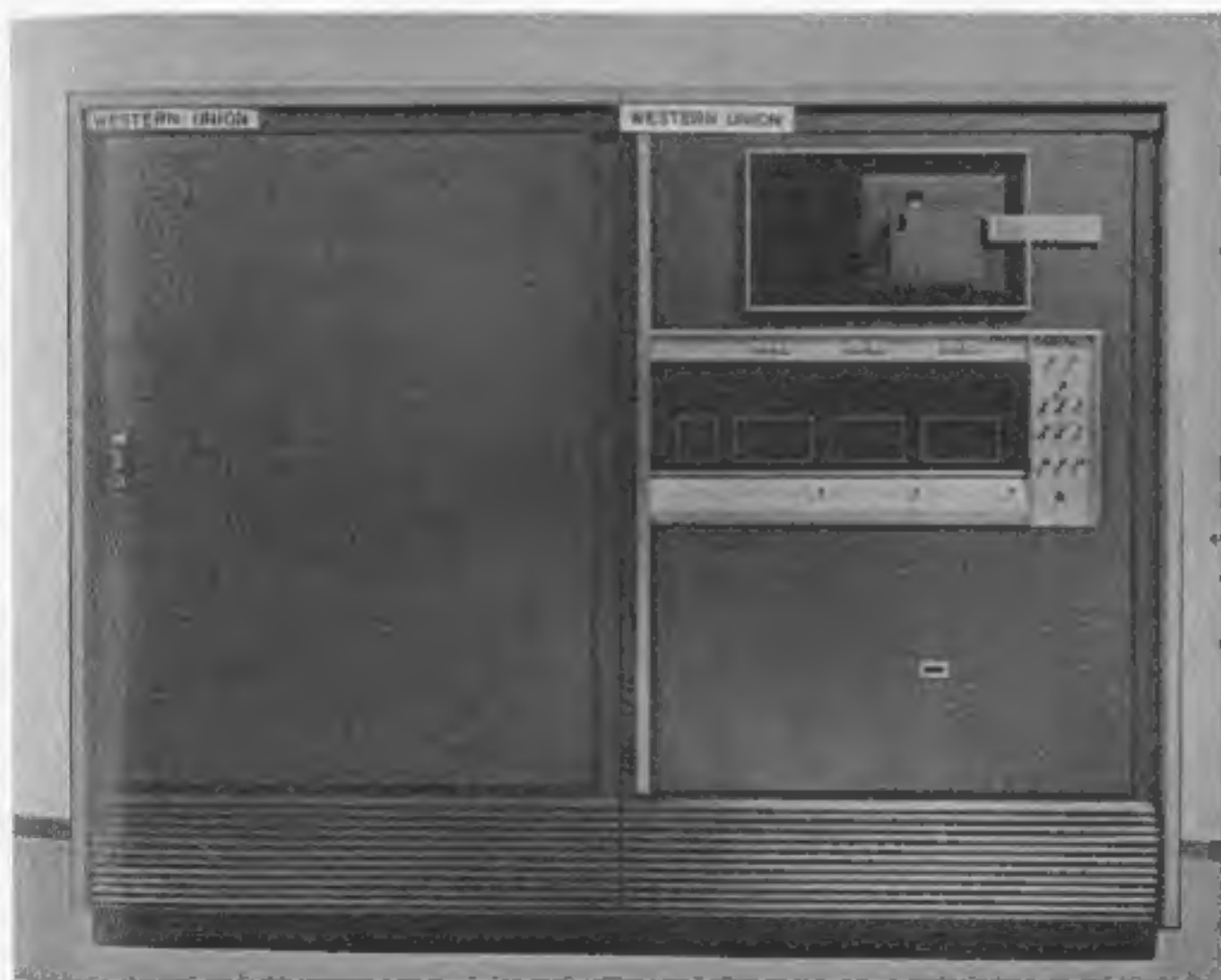

Figure 3. The Western Union 301 Processor

modules to a maximum of 32,768 words. These additional memory modules plus an additional input-output buffer channel are housed in an Auxiliary Memory cabinet. The additional memory modules may be added to the basic machine in increments of 8,192 words and may be wired directly to the control circuitry of the machine.

This processor is a solid-state, single-address, parallel-binary machine, and has a storage read/write cycle time of 6.4 microseconds and an average instruction execution time of 15 microseconds. It has a 12-bit word length and an instruction repertoire of 130 instructions. Information can be exchanged between the computer and input-output devices at any rate up to 70,000 computer words per second.

In addition to a normal channel, a buffered input-output channel, is part of the basic machine. Information input-output operations via the buffered channel may be carried out independently of the main computer program once the program has initiated the operation. This buffering capability includes addressing capabilities for selecting the desired peripheral device and registers for transferring the information.

Four interrupt lines, two internal and two external, are provided with the basic machine. When an interrupt signal occurs on one of these lines, the processor automatically executes a "jump" instruction to a subroutine stored in one of four fixed memory locations, depending on the line which generated the interrupt.

The operator's control console consists of a display panel and a switch panel mounted on the front of the processor for accessability by the operator. The display panel contains three windows in which the contents of nine registers are displayed in octal numbers, using Arabic numerals. Buttons are provided below these windows for clearing the registers and entering data into the various operational registers. The switch panel contains the power and mode switches. The "Enter-Sweep" switch permits the entering of data into core storage or the examination of storage contents. The

"Load-Clear" switch is used to load a program from the high-speed paper tape reader to clear the computer. The "Run-Step" switch is used to operate the computer at high speed or to execute one program step each time the switch is manually pressed.

Program Systems

A symbolic assembler program is used with this machine to provide for full symbolic coding, automatic address correspondence, code-error checking, and listing of source and object programs. Full machine language for the 301 is available in symbolic operation codes.

Pseudo operations control the assembler and its translation of the source program.

Figure 4. Communications Multiplexer

Communications Line Multiplexer

Since all communication circuits are under program control, the 301 System is capable of terminating a variety of different types of communication lines including full or half-duplex way circuits, direct subscriber circuits, or inter-connections to line switching networks such as Telex or Broadband Switching.

Each communication line is terminated in a line buffer which functions as a character storage register for information transfer to or from computer memory. Each buffer is set to operate at the particular speed and code of the communication line to which it is connected. Communication line buffers are housed in the Communications Line Multiplexer[1], shown in Figure 4, and are packaged in modular form. Each module is capable of housing from one to eight line buffers that may terminate lines of various speeds up to 2400 bauds and codes up to 8 bits per frame. A maximum of 24 line buffers can be accommodated in one Multiplexer. As many as 4 Multiplexers can be connected to one computer input-output channel. This unit is described in detail in another article entitled "Communications Multiplexer for Computer Switching Systems" by J. Elich and J. J. McManus on page 54 of this issue.

Magnetic Drum Memory Unit

The Magnetic Drum Memory Unit, shown in Figure 5, was especially designed for Western Union's communications applications. This unit is primarily used for in-transit storage of messages, but is also used for storing tables and status information necessary for routing and recovering procedures. The capability of the unit can be expressed as follows:

Storage Capacity—up to 524,288 characters
Word Transfer Rate—29,700 words/sec.
Average Access Time—17.3 milliseconds.

Fixed-head type drums are used in the W.U. 301 Computer Switching System because they provide considerably more reliable service than can be obtained from moveable head devices, such as magnetic disc files.

Since the function of the drum is primarily to provide intransit queueing storage, the storage required is dictated by the relationship between switching center delivery capability (number of lines and their speed) and the access time to the bulk storage tape systems. If required, several drums can be used in one system to provide multiple, rapid-access storage and retrieval.

Additionally, the housekeeping requirements for the drum (locator tables, etc.) make it mandatory that excessive drum sizes be avoided. Main memory size and time are very costly. In addition, excessive drum size would seriously impede the overall system efficiency.

Figure 5. Magnetic Drum Unit
(Interior View—Front Door Removed)

Magnetic Tape Handler

Magnetic tape is the bulk storage media used in switching applications such as the 301 System, where the administration of traffic and the maintenance of journals is required. The Magnetic Tape Handler, shown in Figure 6, may be assigned to one of four types of storage.

The number of tape handlers used in any system varies with the needs of the system. However, the minimum complement of tape handlers is four, which are used for four types of storage, such as:

1. *Journal Storage* The Journal tape handler is used to retain a complete record of all messages handled by the system. Entries are made in the journal as each message is delivered. The message is retained in in-transit storage on the Magnetic Drum Memory until a complete copy is filed in the journal storage.

2. *Intercept Storage* The Intercept tape handler is used when routine maintenance, "station closed," or other temporary station condition which is normal to the operation of any switching system occurs. Messages addressed to these stations, are intercepted and held in Intercept Storage for subsequent delivery. This magnetic tape handler has a capacity of over 8 million characters, and is used as temporary storage for any traffic not immediately deliverable.

When the supervisor wishes to "close-out" a station, the following procedure is employed: A special message is sent via the supervisory position to the processor to intercept all messages addressed to the particular station. Thereafter, all messages addressed for this station will be recorded on the "Intercept tape" and saved for later retrieval and delivery.

In order to retrieve and deliver information that has been saved in "Intercept Storage," the supervisor sends a special message to instruct the processor to retrieve all messages for a particular station.

3. *Spillover Storage* The continued receipt of many multiple address messages for an extended period could result in an unbalanced traffic pattern, with received traffic far exceeding delivered traffic. In such a situation, the queue area of the drum might be exceeded; thus, it is necessary to provide a reservoir storage as support for the drum. "Spillover tape storage" offers an economical means of providing this support. When drum thresholds, as set by the Master Executive program, are exceeded, all subsequent traffic received at the switching Center is filed on the Spillover tape, and stored until space is again available on the drum, at which time it will be automatically retrieved and delivered.

4. *Auxiliary Storage* This tape handler is used in conjunction with the intercept and spillover tapes when performing tape search operations. New information, entering the system scheduled to be written onto the Intercept or Spillover tape, is temporarily recorded on the Auxiliary tape while a tape search is in progress. With this arrangement, information re-
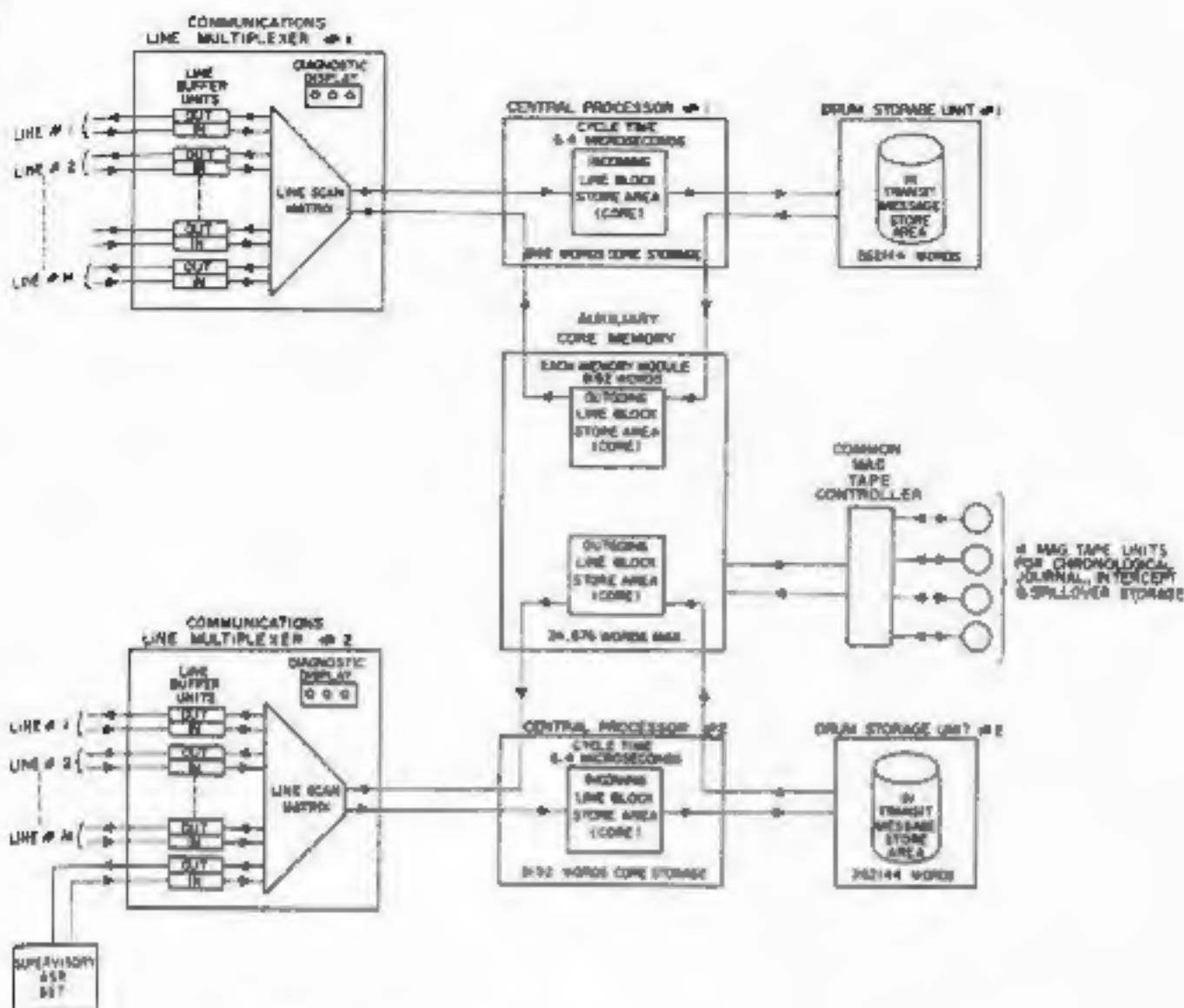
Figure 7. Data Flow through a Duplexed 301 Switching Center
(showing System Configuration)

trieved from storage and tapes can be rewound without decreasing system efficiency.

System Operation

The following is a detailed description of the step-by-step functions performed by the various components of the system to accomplish the acceptance, routing, code conversion, and delivery of messages.

Equipment for a typical 301 Switching Center, was shown in Figure 1. However, two 301 central processors can be arranged to function independently, each with its own 8,192 word memory. In addition, they may share on a direct access basis, an auxiliary core memory of up to 24,576 computer words. This arrange-

ment, shown in Figure 7, enables both processors to have access to common peripheral equipment and to also function independently with their own exclusive peripherals. The overall effect of this configuration is a computer system with 40,960 computer words of memory, an average instruction execution time of 7.5 microseconds, and 5 input/output channels each capable of operating at 70,000 words per second.

Line Servicing

Each line served by the Message Switching Center terminates in a line buffer. By simple adjustment, the line buffer can be arranged to:

1. Accept signal speeds ranging from

low speed telegraph to 2400 baud data;

2. Accept any serial coding consisting of 1, 2, 3, 4, 5, 6, 7, or 8 intelligence units;
3. Operate in a simplex, duplex or half-duplex mode.

The bits transmitted over a line to the Switching Center will be stored in the receiving section of the buffer reserved for the particular line. The buffer will continue accepting bits until a complete character has been stored. It will then transfer this character to the computer input/storage section of the line buffer unit, and indicate to the computer that a character is ready for insertion into memory.

If the character is valid, the computer will then convert the code of this character into a common system code and store the character in an area of core memory assigned to this line. This area is divided into two blocks of 32 computer words, each computer word is capable of storing two data characters.

The computer will examine the character, as well as the previously stored status information for the line, to determine whether this is the end of a message. If the end of a message is detected, the computer will make an entry, by priority, in the message waiting tables. This will indicate a complete message is in the system for delivery.

As each input character is transferred to the computer from the Multiplexer, the status of the output buffer for this line is also forwarded for analysis (whether or not a new character is required). If a new character is required by the output line buffer, the outgoing line block store area for this line is tested to determine if any data is waiting to be sent. If data is present in the outgoing line block store area, the computer will load the next character to be sent, and convert this character from the common system code into the proper character code for this line. The character is then transferred by the computer through the Multiplexer to the proper output line buffer for serial transmission at the appropriate line speed of this circuit.

Input Block Servicing

As the characters are entered in the core memory area (2 blocks of 32 words each) assigned to the line from which they are received, the computer will maintain surveillance to ascertain when an input block area has been filled. As each incoming block area per line is filled, it must be moved out of core memory and onto the drum before the second block is filled. Therefore, the time allowed to move out a full block, before characters are again stored into it, is the time required to completely fill the second block.

Block size (number of characters of storage) and block service time (the frequency of checking each area to see if it should be moved) are determined by each particular system requirement. A typical system uses a block size of 60 characters and a block service time of 3 seconds.

Routing a Message

After a complete message has been written on the drum by the Input Block Move Program, an entry is made in the Message Waiting Table. This table is used to alert the routing program, that messages are waiting to be routed. It also contains the address of where this particular message is stored on the drum. Blocks will be removed, one at a time, from the drum to core memory starting from the first block until the entire message header has been examined and all addresses have been processed. The information does not have to be rewritten onto the drum, since the read process does not destroy the data recorded there. As each address is processed by the routing program, an appropriate entry will be made in the Outgoing Queue Table for the proper line to which this message is to be sent. This table is used by the Output Block Move Program to determine which message is to be delivered to a particular outgoing circuit.

Output Block Servicing

The computer will maintain surveillance of the block area for each outgoing line and, as an output block area becomes empty, it will examine the Outgoing Queue Table for this circuit to determine

Figure 8. Master Executive Program

if there is more information on the drum for this particular line. There are two blocks, 32 words each, in core memory assigned to each outgoing line block store area. As one outgoing block is being emptied by transfer to the Multiplexer, the output block move program will fill the second block. If the second block is not filled before the first block is empty, circuit inefficiency will result due to the unavailability of characters to deliver to the output line buffer

Program Description

Five major programs are required for operating a 301 Switching Center:

Master Executive—The Master Executive program provides for all memory and input-output supervision. It contains all sub-routine branch tests, real-time counters, memory and peripheral threshold constants and status flags. This program consists of a series of concentric loops and is used to invoke appropriate sub-routines based on the system status at any given moment. Figure 7 is a flow chart of the Master Executive Program outlining the various supervisory actions under its control

Line Service Program—The line service program moves data from the Multiplexer into the input buffer area of the core memory and from the output buffer area of core memory to the Multiplexer. It may be divided into two parts or routines

a) The common routines are assembled in the operating program to provide all common elements of control or service to each different type of line For example, if all lines associated with a particular Center were operating in the 5-level code using standard teleprinter procedures, only one common line service routine would be required. However, if one or more lines connected to this Center were to operate in the IBM four-out-of-eight code, for example, a second routine would be required.

b) The per-line routines are dependent upon the type of line involved and consists of memory buffer areas, memory loading constants, and circuit control constants, such as message number or block count, etc. The per-line memory requirement will also vary on the basis of whether the line is full duplex or half duplex.

Input Block Move—This program is invoked by the Master Executive program when an input buffer area of the magnetic core memory is filled. This program empties that buffer area, and stores the information on the magnetic drum. The Input Block Move Program requires a fixed number of words of memory for its common portion plus additional words for constants and flags for each line

Output Block Move—This program is invoked by the Master Executive program when an output buffer area of core memory, is empty, and additional information is in queue for delivery to the particular line. The common portion of the Output Block Move program requires a fixed number of computer words. In addition, more words for constants and flags are required for each line connected to the system.

Routing Program—This program includes the message routing routine, the routing tables, the queue tables, drum overflow chronological journal, message intercept and recovery routines This program consists of a common program plus a fixed number of words for each routing indicator

Memory Criteria

The entire programming system, with one minor exception—the decoding criteria for group code routing indicators, has been designed to be retained in core memory This will be kept in a locked portion of the magnetic drum reserved for this purpose. This approach was decided upon after careful study of the alternatives which generally revolve around program overlay techniques. It was found that the limited economy gained in memory size, by keeping the less frequently used sub-routines in peripheral storage was far out-weighted by the accompanying decrease in capability of the system due to the loss in available time and the reduction in system reliability due to the dependence on a peripheral unit for program support.

Other Applications

Besides the standard commercial communications applications discussed in this article this system is very well suited for military application as well as on-line real-time data processing operation. Since this system is leased on a twenty-four hour basis the dual role of part time communication center and part time data processing center is highly significant. This system can be used during normal business hours, i.e. 8 A.M. to 5 P.M., as a store-and-forward switching center and either as an on-line or an off-line (no communication capability with out-stations) data processing system the remaining part of the 24-hour day.

The processor utilized in the 301 System is a general purpose computer that is fully capable of performing complex data processing functions. This approach allows the 301 System to be used not only for communication applications but also for a wide variety of data processing applications as on-line, real-time data processing, off line batch processing or on-line, real-time data retrieval. These are but a few of the many applications of computer-type systems with communication capability.

* * * *

References

A. me Telegraph Sw h ng S stem Plan 5 A
r S t el am Weste n Th IC N RE
o W n N A
a Communi ca n M erre f the ll Sw h g
System, J Eloh and J J McMa h Am e for
TECHNICAL REVIEW Vol 0 N Au 6

System Features

The special features of the 301 System are:

• Many communication circuits of mixed speeds and codes can be terminated

• The modular design provides for economical expansion

• Messages of various formats can be accommodated

• Routing indicators may be of any practical length

• The Supervisor can add, change or delete routing instructions of the processor by control messages sent from the operator's console

• Messages having invalid routing indicators are automatically intercepted by the 301 Processor and the operator is advised of this condition.

• Multiple-address messages having a mixture of valid and invalid routing indicators can be sent to all legitimate addressees and the operator will be advised as to which addressees are incorrect.

• Each incoming message is checked for proper sequence number to protect against loss of message

• Automatic error checking can be provided for circuits terminating outstations which use special error checking codes

• Incoming messages will be immediately sent to the addressee as soon as the routing information is processed provided that the desired circuit is available and no other previously received messages are waiting for the circuit

• Time and date can be added to the heading of each message as it is sent to the called subscriber

• Time of message receipt and delivery can be stored along with the entire message for off-line statistical studies

• Several levels of message priority can be accommodated and if desired low priority messages can be stored for later delivery during low traffic periods.

• The power, speed and flexibility of the 301 Processor is enhanced by existing programming aids which include symbolic assemblers, compilers and interpretive systems

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Communications Multiplexer
for
Computer Switching Systems

A Multiplexer, when used in a computer-controlled switching system, has the function of transferring data between communication line terminals and a computer on a real-time basis. The Communications Multiplexer designed by Western Union, serves as an interface unit which provides this real-time Input-Output control between the communications line equipment and the Computer such as in the new Western Union 301 Computer Switching System.[1]

The development of this Multiplexer fulfills the need for a broadly applicable, reliable, fail-safe, and flexible switching link between the various Western Union communications networks and the computer

The Multiplexer cabinet, shown in Figure 1, contains two main circuit groups, the Input/Output (I O) Line Buffers and the Control Circuits. The Input/Output Line Buffer unit provides the interface between the external communication lines and the computer. An Input Line Buffer (I) receives data serially from the line and converts it to parallel form for transfer to the computer. An Output Line Buffer (O) receives data in parallel form from the computer and transmits it serially to the outgoing line. Both the bit rate and character length can be selected. Provision is made to accept line signals with 5, 6, 7 or 8 information bits with start-stop synchronization. The bit rate can be set up to 2400 bauds. The Control circuit group sequentially processes the flow of information between the I/O buffers units and the computer or processor

The I/O circuits are packaged in modular form to provide the maximum flexibility for the various system line configurations. Each module can service eight asynchronous communication lines. Each line circuit within the module is made up of one circuit group composed of Western Union Standard Logic printed circuit cards. Line additions are made by installing a card group. The Multiplexer is ge-
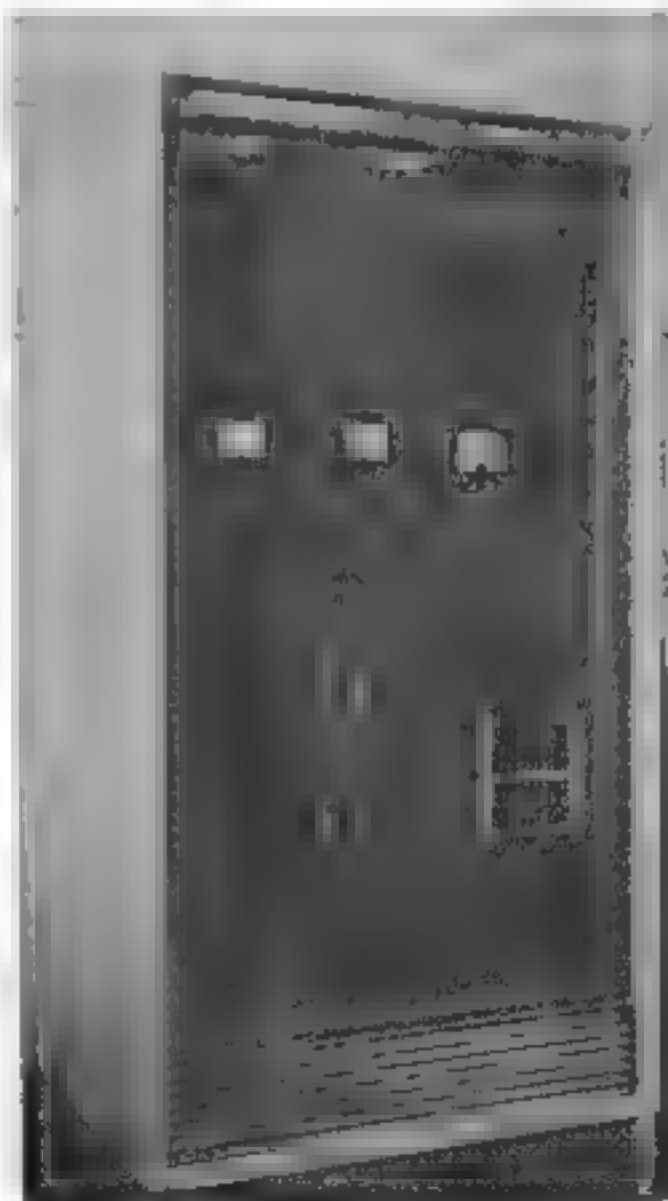

Figure 1   Communications Multiplexer (prototype. front view door removed

signed to accommodate synchronous lines through the use of appropriate line units. One Multiplexer can terminate twenty-four (24) communication lines either simplex, half-duplex or full duplex.

The Multiplexer contains a Real-Time Diagnostic Display circuit which allows supervisory personnel to communicate with the processor. The supervisor directs a code instruction to the computer by means of manual switches. The computer, in turn, sends a code to a visual display at the supervisory position. The code display is used to indicate computer status or to aid diagnosis of faulty equipment operation.

The 301 Computer Switching System can service as many as four multiplexer cabinets. Since each cabinet can service a maximum of 24 lines (send and receive), this means that 4 such cabinets can serve a maximum of 96 lines. It should be observed, however, that many factors such as line speed, computer memory capacity, patron messages processing requirements, etc., determine the number of lines that can be serviced.

General Principles

In order to clearly understand the general principles of the Multiplexer circuits, the major signal flow is shown in the System Block Diagram of Figure 2. This diagram shows the major components of the Multiplexer. All communication lines are connected to a Line Terminal Unit from which information is fed into the Multiplexer. The Multiplexer controls the communication lines and communicates with the processor over I/O channels. Let us consider the flow of information from the input lines to the computer and from the computer to the output lines.

Input Buffer Block

A Line Terminal provides facilities for terminating the incoming and outgoing communication lines. The Input Line Buffers connected to the line terminal convert the serially-received information bits and stores them in parallel. The parallel-stored character is then transferred to the computer under direction of the control circuits. The control circuits provide the commands to transfer information between the input character buffers and the computer.

Output Buffer Block
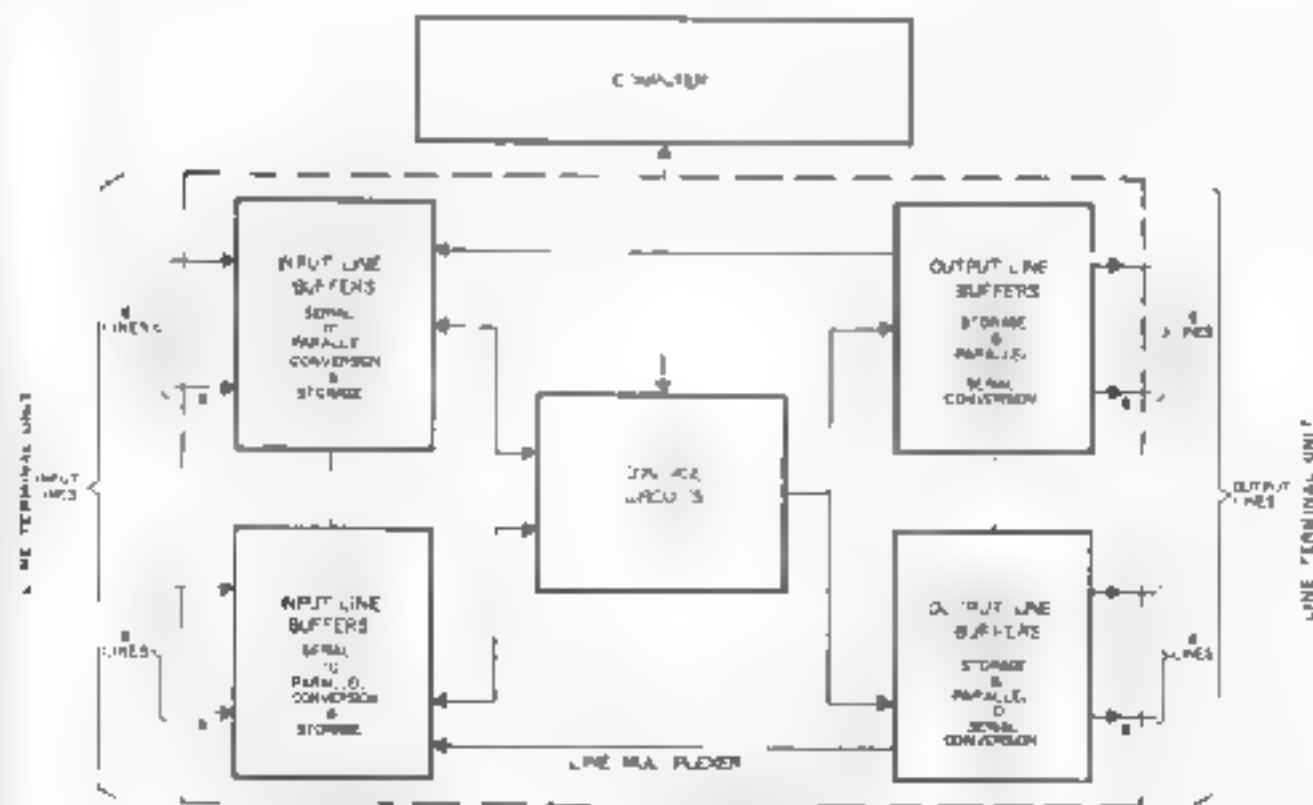
Information from the computer is
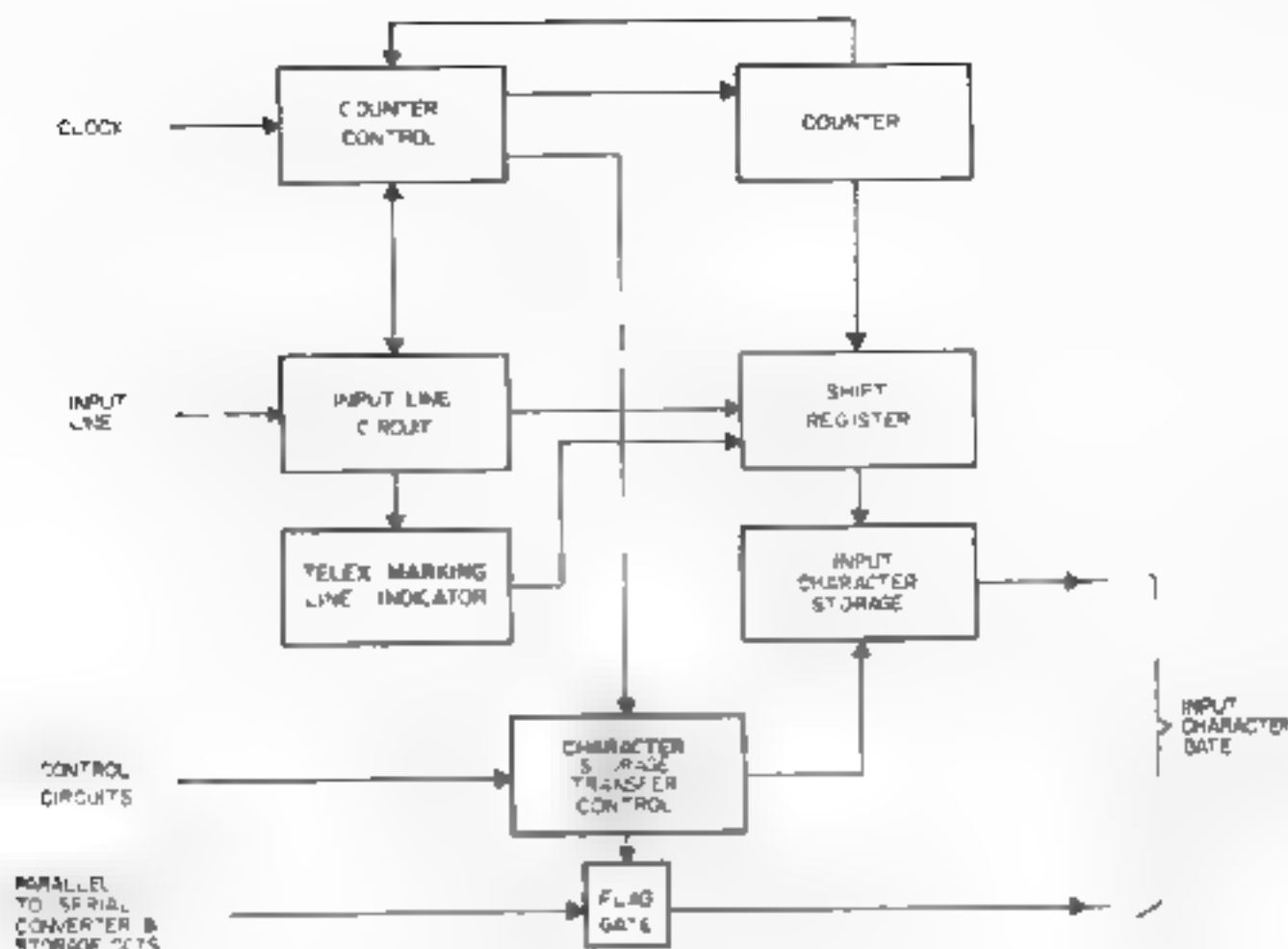

Figure 2. System Block Diagram

Figure 3. Input Line Buffer Block Diagram

transferred in parallel under the direction of the control circuits to the Output Line Buffer storage circuits. The Output Line Buffer converts the stored outgoing character to serial form and transmits it to the output lines.

Input Line Buffers

The circuits contained within the Input Line Buffers are detailed in the expanded Block Diagram of Figure 3. The outputs from the communication lines are connected in groups of 8 to the serial-to-parallel conversion and storage circuits. The outputs of the Input Line Buffer character storage circuits are connected to the Computer Input Buffer gates, shown in Figure 4, for transfer to the computer.

The Input Line Circuits in Figure 3 control the flow of line signals to the Shift Register. The Counter Control controls the sequencing of the information bits to the counter with respect to line speed and code. The Counter provides the timing sequences to load and advance the storage of the information bits in the Shift Register. The serial-to-parallel conversion of the information bits of each character is performed by the Shift Register. An Input Character Storage circuit acts as a buffer storage unit for the parallel character information stored in the Shift Register magnetic cores. A Character Storage Transfer Control generates the signal to present information from the Input Character Storage to the computer. The Flag Gate, in Figure 3, signals the Computer as to the condition of the Output Line Buffer Storage circuit.

A Communication line circuit used as a Telex Line, activates the Telex Marking Line indicator circuit which detects revertive pulses.

Control Circuit Block

The signal flow between circuits of the Control block is shown in Figure 4. Observe that the Control Block is made up of three groups of circuits, the Input Cycle, Selection and Output Cycle, and the Scanner. Let us consider these groups

Figure 4. Central Circuits Block Diagram

(a) Input Cycle

These circuits control the signal flow between the Input Line Buffers and the input to the computer The information in the input line buffer storage is transferred into the computer by means of the Computer Input Buffer gates. The receipt of an Input Request signal from the computer causes the following events to occur; (1) the Input Line Buffer Control transfers the incoming data to the computer, and (2) the Input Ready generator responds with the Input Ready signal when a character is present on the computer input cable.

(b) Selection and Output Cycle

The circuits in this group perform the following functions (1) control the signals between the computer output and the Output-Line Buffers, (2) decode the Multiplexer address, and (3) generate signals to step or reset the Scanning circuit. The Computer Output Buffer Drivers provide circuit isolation and signal level conversion similar to the Input Buffer Gates in the Input Cycle. Each Multiplexer has its own address code. When the computer selects a particular Multiplexer, it outputs a specific selection address which is detected by the Address Decoder The Output Resume Generator is activated when the Multiplexer detects its selection address code or, when selected, it receives and accepts an Output Word from the computer. Upon receipt of a complete word in the Computer Output Buffer Drivers, the Output Line Buffer Control generates a Valid Word Signal, which transfers the information bits to the Output Character Storage of the selected Output line Buffer Unit. The 40 Interrupt Generator is a unit that develops a series of uniformly timed pulses. When these pulses are sent to the computer, it responds to the Multiplexer with a "Function Ready" signal and initiates a multiplexer selection sequence.

(c) Scanner

Each I/O Buffer is numbered in sequence. The purpose of the Scanner, indicated in the Control Circuits Block Diagram Figure 4, is to sequentially select these buffers. The Scanner Control circuits step the Scanner Counter upon the receipt of a decoded address signal and specific information bits from the computer

Reset circuits are used to return the Scanner to the home position in three ways. (1) under command of manual reset switch, (2) upon receipt of a Function Ready signal from the computer, and (3) from a signal indicating that the counter has reached the next step after the last line count.
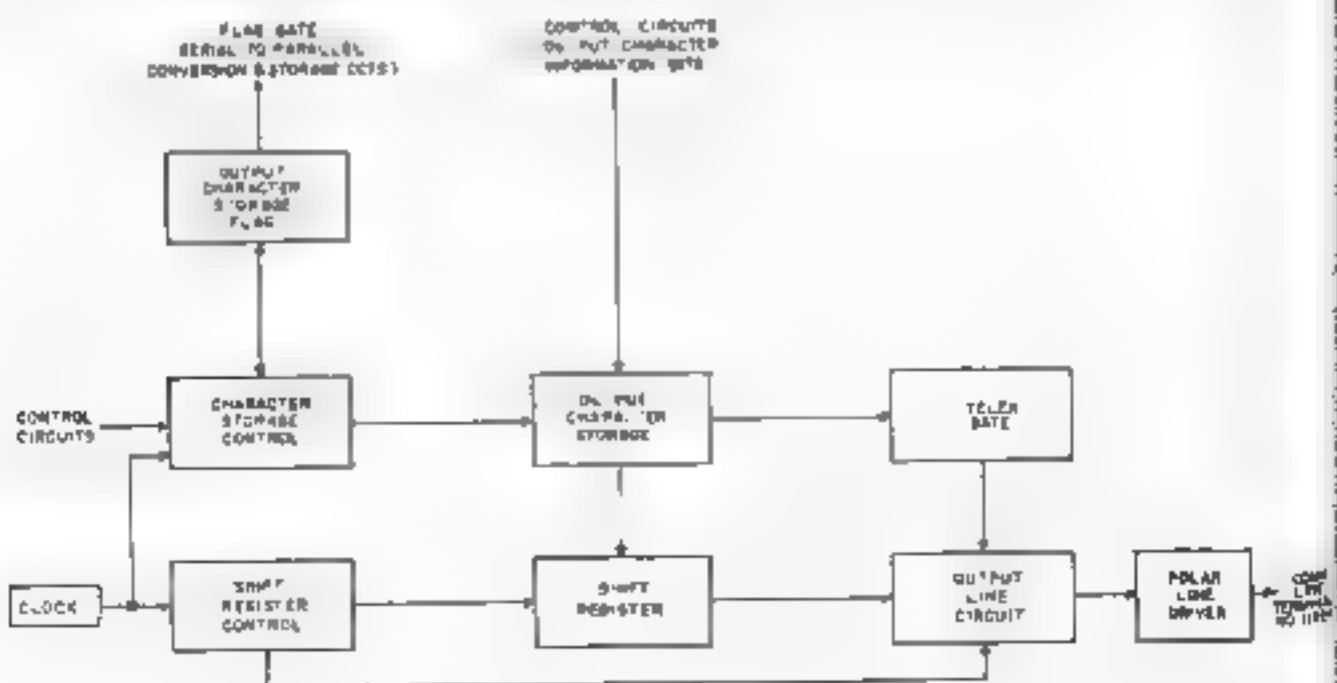

Figure 5. Output Line Buffer Block Diagram

Output Line Buffers

Figure 5 shows a detailed Block Diagram of the Output Line Buffer circuits which convert the parallel stored information from the computer to serial form for the transmission to the communication lines.

The Output Character Storage temporarily stores the Output Character Information bits from the computer, prior to transfer of this information to the Shift Register. The Character Storage Control circuit causes the Output Character Storage to load the Shift Register.

Buffering between the Shift Register and the Communication Lines is supplied by the Output Line circuits. The Telex Gate supplies, within a specified time, a revertive signal to a Telex Communication Line. The Flag Gate is used to indicate to the computer that an Output Buffer is available.

Clock pulses control the line speed and coding of the Output Line Buffers as well as the counters and shift registers of the Input Line Buffers. The clock pulses are derived from signals generated by standard Western Union oscillators.

Operation

The following description pertains to buffered operation of asynchronous transmission lines terminated at Western Union Line Terminal Equipment and extended from there to the 301 Communication Multiplexer connected to a computer. Each communication line is terminated in the Multiplexer in a character buffer which has the capability of storing two complete characters plus the start and stop pulses. The Multiplexer is connected to the computer via an Input and Output Cable and is capable of alternate, two-way transmission. The character information and control bits, placed on the computer input cable by the multiplexer, constitutes the Input Word. The information and control bits placed on the output cable by the computer and received by the Multiplexer makes up the Output Word.

Selection

The Multiplexer notifies the computer that it needs servicing by sending out a 40 Interrupt signal. Then the Computer, under program control, selects the Multiplexer by sending a unique external function code over its normal channel on the output cable. When this code is recognized by the Multiplexer as its function code, it removes the 40 Interrupt signal. Selection is completed and all the signal levels are returned to normal.

Input Word

After the Multiplexer is selected, the computer sends out the Input Request signal. This is sensed by the Multiplexer which gates the stored information of the input buffer of line #1, for example, on the proper Input Status and Information leads of the Computer Input cable. Let us assume that the Input Word placed on the computer input cable is received from a communication line having an 8-level code. Figure 6 shows a representation of this Input Word with the information, control, start and rest bits as positioned on the computer input lines.

| 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | BIT POSITION |
| C | C | S | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | R | 8-LEVEL CODE |

C = CONTROL BIT   S = START PULSE   R = REST PULSE

Figure 6. Input Word

The control bits are used to inform the computer of multiplexer status. For example, Bit 10 is a control bit used primarily for lines connected to Telex Trunks. Bit 10 informs the computer as to whether or not the receiving side of the line has been in the spacing condition since last serviced by the Multiplexer.

After the Input Word for this line No. 1, has been gated onto the Input Status and Information Leads, the Multiplexer generates the Input Ready signal. This condition is recognized by the computer, which stores the information on the Input Status and Information Leads and the computer terminates the Input Request.

When this is sensed by the Multiplexer, it restores all the signal lines to normal levels.

Output Word

The computer sends an Output Word to the Multiplexer provided that a character is available in the computer. A Typical Output Word information and control bit positioning for an 8-level code is illustrated in Figure 7. Observe that in contrast to the Input Word the start pulse is now on computer line 11 and the control bits are on lines 1 and 0.

| 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | BIT POSITION |
| S | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | R | C | C | • LEVEL CODE |

C = CONTROL BIT   S = START PULSE   R = REST PULSE

Figure 7. Output Word

When the computer wishes to send an Output Word, the information is gated by the computer onto the twelve Output Function and Information lines and then the Information Ready signal is generated. The Multiplexer senses this condition, interprets the information contained in the Output Word, performs the required functions and then generates the Output Resume, which acknowledges the receipt of the Output Word. The computer senses the Output Resume signal and all the lines are restored to normal. When this happens the Output Resume Line goes back to normal level. Bits 0 and 1 in the Output Word are used as control information and bits 2 to 11 are used for data transfer.

High Speed Synchronous Transmission

For operation on high speed synchronous communication lines a special line terminating unit is required. This unit can meet all the requirements necessary for this mode of operation. It operates at any line speed up to 4800 baud. Line equipment which will soon be available can extend this range up to 48,000 baud. Parity error detection and automatic character framing is done under internal logic circuit control. The unit is compatible for operation with any Western Union Modem.

Special Features

■ Fail-Safe

Dual input/output control logic is provided as a standard part of the Western Union Multiplexer to make the system fail-safe.

● Reliability

Extensive use of magnetic cores minimizes the number of semi-conductors required thus increasing the reliability of the unit.

● Fall-Back

Fall-back send receive electronic distributors are also provided. Failure of a distributor (which affects only one line) is detected instantly by an automatic alarm which alerts the supervisor who can quickly and easily place a fall-back distributor in operation.

● Compatibility

The Multiplexer design makes it compatible for use in interfacing and buffering between any currently used Western Union communication system (Telex Plan 57, etc.) and the 301 Computer.

● Adaptability

The 301 Communication Multiplexer can be used as a time division line concentrator by the addition of a group of control circuits.

● Flexibility

The modular design of the Multiplexer logic circuits lends itself to ease of expansion and flexibility to meet the various system and communication line requirements.

Acknowledgement

The authors wish to acknowledge their indebtedness to their engineering colleagues of the Switching Systems Division who contributed many of the technical details of the Multiplexer design.

*   *   *   *

Reference

1. Western Union 301 Computer Switching System, P. F. Manning, Western Union TECHNICAL REVIEW Vol. 19 No. 2 April 1965.

Mr. John Elich, Senior Project Engineer in the Switching Systems Division of the Plant and Engineering Department, has been actively engaged in the design of switching circuits and equipment such as the 30x Multiplexer concentrator, the standardization of Western Union logic, the solid state selectors, the 210 System, EMATS and Plan 57.

He received his BEE from the College of the City of New York, in June 1956. He joined the Western Union Telegraph Co. in August 1962.

Mr. J. J. McManus, Senior Project Engineer in the Switching Systems Division of the Plant and Engineering Department, has been engaged in the development and engineering of automatic switching systems such as facsimile concentration, facsimile relaying by means of magnetic storage, Plans 57 and 59 and EMATS.

He joined the Western Union Telegraph Company in October 1962 and was assigned to the staff of the Switching Development Engineer of the D & R Department.

Mr. McManus received his BEE in Electrical Engineering from the College of the City of New York in February 1938.

He holds a registered New York State Professional Engineers License and is a senior member of Institute of Electrical and Electronic Engineers.

Western Union Participates in CCIR
Space Communications Meeting

For many years, Western Union representatives have participated in the activities of the International Consultative Committee on Telegraph and Telephone (CCITT) and of the International Consultative Committee on Radio (CCIR), which organisations comprise the International Telecommunications Union (ITU). These committees perform their work in Study Groups activated to deal with a wide variety of subjects. They are composed of specialists assigned by the administrations of member countries.

Western Union is approved by the U. S. Department of State and has been accepted by ITU as an internationally recognized private operating agency. This status enables us to take part in the study programs of both CCITT and CCIR, all papers are mailed to us from Geneva as they are circulated to member governments, we have a vote in international meetings; and above all we have signified our intention to collaborate and cooperate with world wide communications organisations for the improvement and expansion of world communications.

CCIR Study Group IV—Space Communications, activated in 1961, met in a first international meeting at Washington, D.C. in 1962 and has just had a second meeting at Monte Carlo, Monaco (Feb. 9 to March 2, 1965). Approximately 120 delegates and 80 other registrants attended the meeting. This very active Study Group studied over 160 contributions, revised, voted upon, and distributed these to member countries for consideration. In the course of the three-week meeting over 100 temporary documents were generated by working parties. These were combined into the final reports and recommendations which now must be considered by all countries before final adoption at the next Plenary Assembly of CCIR to be held in Oslo, Norway, in 1967.

CCIR Study Group IX—Radio Relay Systems, is a somewhat older Study Group which divides its assignments into two parts, the line-of-sight microwave systems and the forward scatter systems. This Study Group also met at Monte Carlo for one week with the Study Group dealing with space communications to process matters of joint interest.

In general the study program for these two Study Groups included technical characteristics of radio relay and communication satellite systems; frequency sharing problems, including power level limitations, interference reduction, modulation techniques, multiple access arrangements, etc.; telemetry, telecommand and control; meteorology and radio astronomy; and terminology and definitions.

J. Z. Millar.
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NEW

8-LEVEL TELEPRINTERS AND ASR SETS

Part II: Model 35

The heavy-duty Model 35 line of 8-level equipment includes receiving-only (RO) teleprinters, keyboard send-receive (KSR) teleprinters, and automatic send-receive (ASR) sets. In general, the same basic components are available for the Model 35 ASR sets as are used in the Model 28 5-level equivalents. Typing and non-typing reperforators are available either as self-contained units or as part

of an ASR Set. Either single-shaft (LXD) or dual-shaft (LBXD) distributor-transmitters are available for the Model 35 ASR set and two distributor-transmitters can be used in an ASR set. It is also possible to simultaneously punch tape off-line and receive page copy on-line.

The Model 35 ASR set used in the GSA system, shown in Figure 8, consists of a keyboard, a typing unit, a start-

Figure 8. Model 35 ASR Set—GSA System Version

stop reperforator, a dual-shaft distributor transmitter, an answer-back unit, a remote control unit, an electrical service unit, a console, and two motors. The answer-back unit, which is mounted on the same base as the distributor-transmitter, uses the same answer-back drum assembly and distributor face plate that are used in the Model 33 teleprinters. A separate clutch and clutch release magnet are also included in the answer-back unit. A common motor is used to drive both the distributor-transmitter and the answer-back. (The other motor in the set drives the printing and punching units) A relay mounted in the electrical service unit provides a non-contention feature to prevent the answer-back from responding when the who-are-you character is transmitted from its own keyboard. The electrical service unit also contains a selector magnet driver which converts the line signals (either polar or makebreak) to 500 milliampere signals to drive the selector magnets in the non-typing start-stop reperforator. The selector magnet driver which drives the typing unit selector magnets is located in the remote control unit.

Model 35 Keyboard

The keyboard layout for the Model 35, shown in Figure 9, is the same as the layout for the Model 33, described in Part 1 of this article, except that the repeat key is in a different position and the local keys for line feed, carriage return, and back space shown in Figure 9

are not available on the Model 33 sets. The use of the shift and control keys shown in the figure was described in Part 1 of this article.

One of the most interesting features of the Model 35 units is the method used to maintain even parity when the shift and/or control keys are used. In the Model 35 keyboard, the deletion of bit 7 to generate control characters and the inversion of bit 5 to generate shift characters is accomplished mechanically. The mechanisms used to accomplish this and maintain even parity are described in the following paragraphs.

In the Model 35 keyboard, each code bar is coded on its underside by means of notches and projections cut into the bar. When a keytop is depressed, an associated code lever is pivoted so that its rear half moves upward into the notches in the code bar, as shown in Figure 10. Near the end of the stroke, a code bar blocking bail (not shown) rotates counterclockwise and allows the code bars, which are spring-biased to the marking side, to move to the right, *toward* their marking positions. Those code bars which are coded to set up a spacing pulse for the selected key will be blocked when a projection on the underside of the code bar strikes the selected code lever. When a code bar which is coded to set up a marking pulse moves to the marking position, a projection on the upper side of the bar engages an associated transfer lever and rotates it clockwise to its marking position. The positions of the transfer
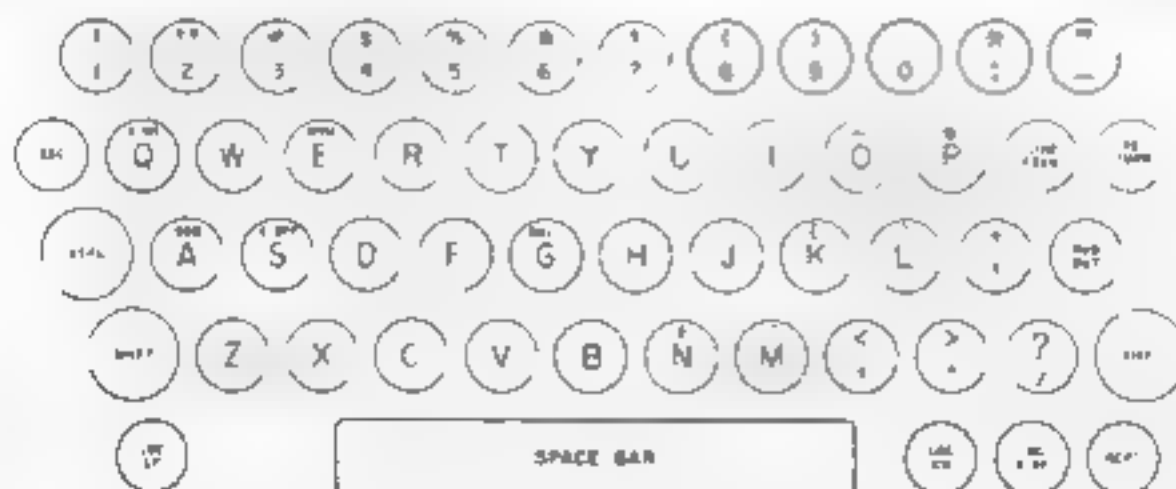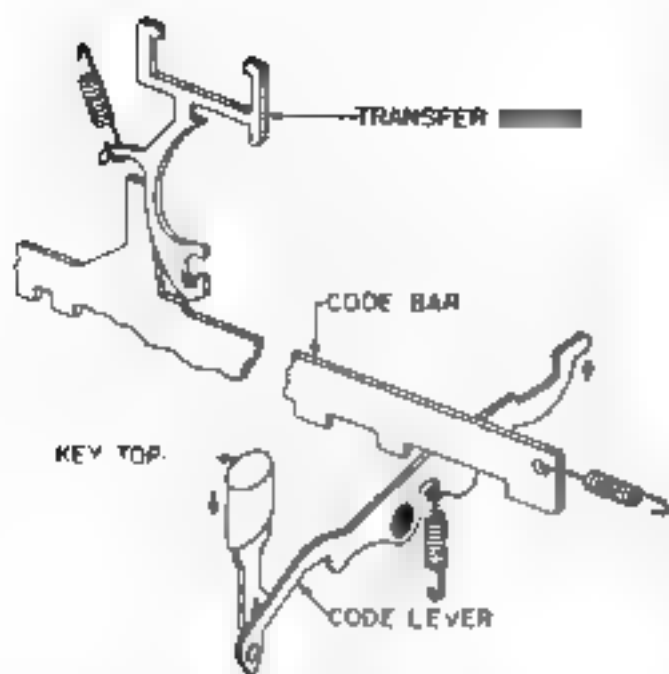

Figure 9. Model 35 Keyboard Layout—GSA Version

Figure 10.
Keyboard Code Bar and Transfer Lever Mechanism

levers subsequently determine the code combination, or bit permutation, transmitted from the keyboard signal generator. The Nos. 1, 2, 3, 4, 6, and 7 transfer levers can be operated only by their corresponding code bars. The Nos.

5 and 8 transfer levers, however, can be operated either by their corresponding code bars or by associated inversion code bars, which engage extensions on the transfer levers. The No. 5 inversion code bar is used to invert bit 5 when the shift key is depressed and the No. 8 inversion code bar is used to invert bit 8 when either the shift or control key is depressed.

Bit Inversion Mechanism

The No. 5 code bar and the No. 5 inversion bar are complimentary-coded that is, if the No. 5 bar is coded to move to its marking position when a specific code lever is operated, the No. 5 inversion bar will be coded so that it is blocked and prevented from moving to the marking position when that code lever is operated, and vice versa. The No. 8 code bar and the No. 8 inversion bar are also complimentary-coded.

When the control key is depressed, the rear of the control code lever moves upward and into the path of a projection on the No. 7 code bar When a character
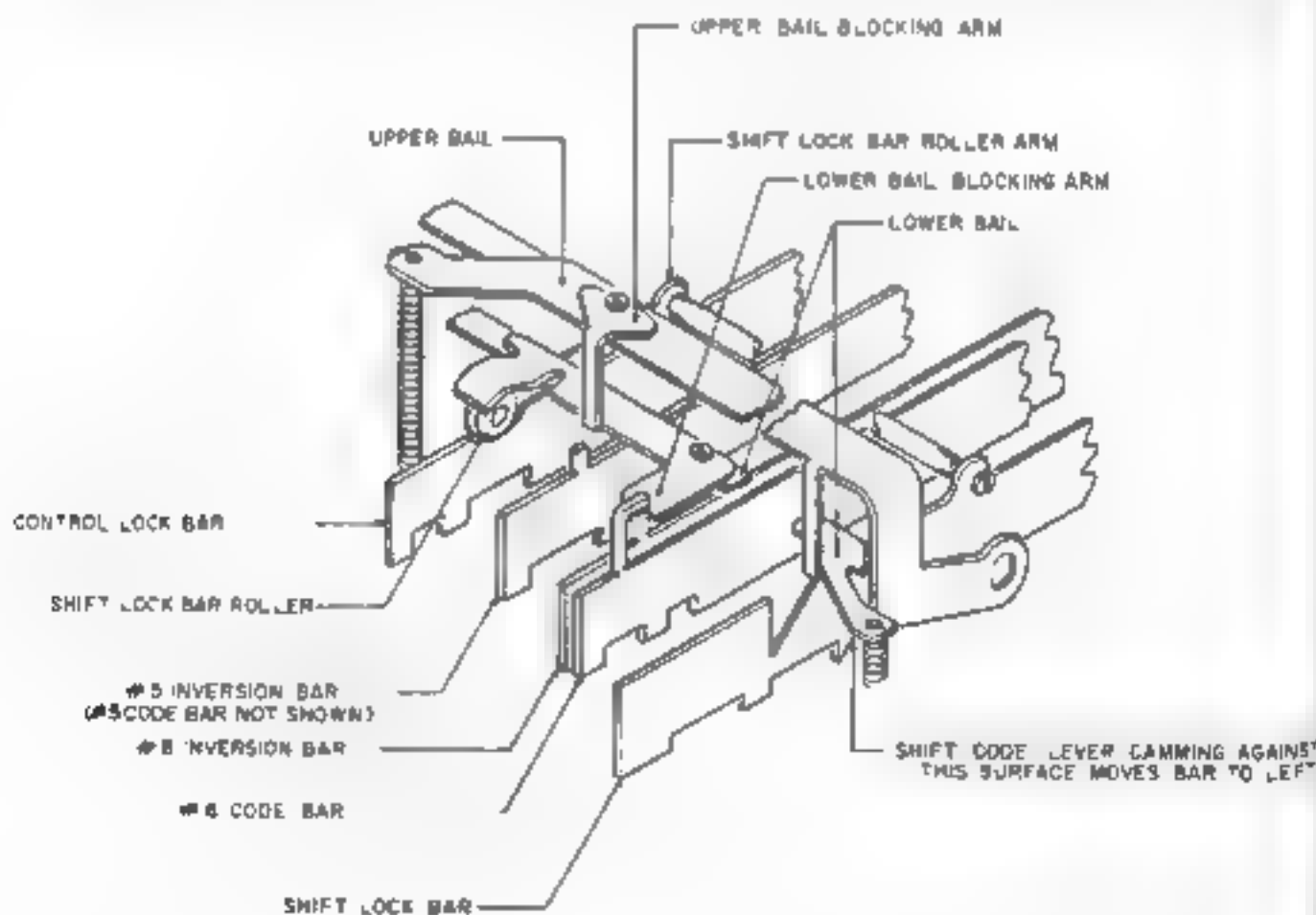

Figure 11   Bit Inversion Mechanism

key is then depressed, the No. 7 code bar will be blocked by the control code lever and prevented from moving to the marking position. Bit 7 will therefore be a spacing pulse, or zero bit, regardless of which character key is depressed

As the rear of the control code lever rotates upward, it engages a saw-tooth shaped camming surface on the underside of a control lock bar and moves this bar to the left. In this position, projections on the underside of the control lock bar block all code levers associated with keys not used to generate control characters.

When bit 7 is deleted, bit 8 must be inverted in order to maintain the even parity. When the control lock bar is in its right hand (unoperated) position, a shift lock bar roller, which is fastened to a pivoted lock bar roller arm, rests on the low part of a curved camming surface on the control lock bar, as shown in Figure 11. But when the control lock bar is cammed to the left by the control code lever, the high part of the curved camming surface moves under the shift lock bar roller and rotates the roller upward. A lower bail blocking arm, which rests on the lock bar roller, is then rotated upward by the roller. When the lower bail blocking arm is in its lower position, the arm is in the path of a projection on the upper side of the No. 8 inversion bar, as shown in the figure. In this position, when a key top is depressed and the code bars subsequently move towards the marking position, the No. 8 inversion bar will be blocked by the lower bail blocking arm. The No. 8 code bar, however, will not be blocked. When the lower bail blocking arm is rotated upward by the shift lock bar roller, the blocking arm moves out of the path of the projection on the No. 8 inversion bar and into the path of a similar projection on the No. 8 code bar. The No. 8 inversion bar is then free to move to the marking position, but the No. 8 code bar will be blocked and prevented from moving to the marking position. Since these two code bars are complimentary coded, bit 8 will be inverted.

When the shift key is depressed to generate a shift character (by inverting bit 5), the rear of the shift code lever engages a saw-tooth shaped camming surface on the underside of a shift lock bar (see Figure 12) and cams the lock bar to the left. At the same time, the shift code lever moves into a notch in the underside of the No. 5 code bar (not shown in Figure 12) and blocks this code bar so that it cannot move to the marking position when a character key is subsequently depressed. When the shift lock bar is in the left position, projections on the underside of the bar block all code levers which are not used to generate either shift or control characters. As the shift lock bar moves to the left, a saw-tooth shaped camming surface on the upper side of the bar engages a projec-
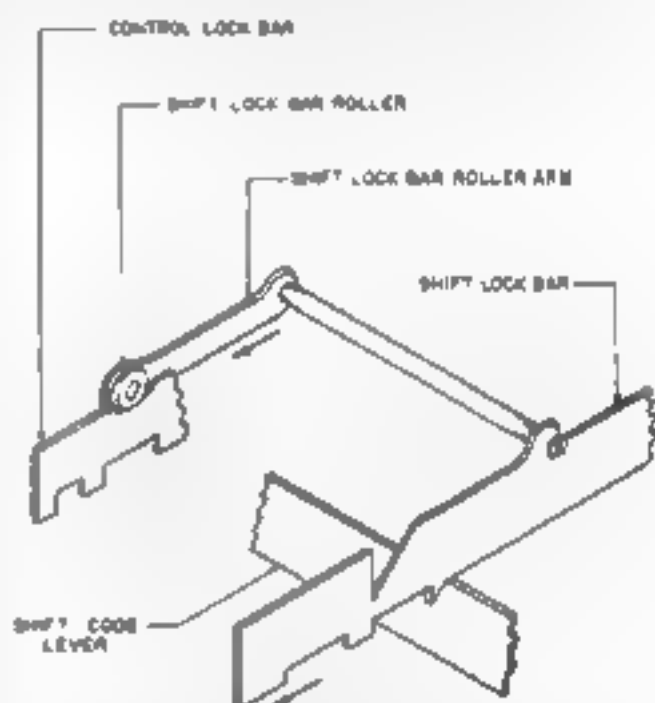

Figure 12. Shift Lock Bar Assembly

tion on the upper bail, as shown in Figure 11, and rotates the upper bail upward. When the upper bail is in its lower position, the upper bail blocking arm, which is fastened to it, is in the path of a projection on the No. 5 inversion bar and this bar cannot move to the marking position. However, when the upper bail rotates upward, the upper bail blocking arm moves out of the path of the projection and unblocks the No. 5 inversion bar. Since the No. 5 code bar is blocked by the shift code lever, bit 5 will be inverted.

When bit 5 is inverted, bit 8 must also be inverted to maintain the even parity. As the shift lock bar moves to the left, the shift lock bar roller arm, which is fastened to the shift lock bar by means of a pivot shaft, as shown in Figure 12, also moves to the left. The shift lock bar roller then moves up to the high part of the curved camming surface on the control lock bar. As the roller moves upward, it raises the lower bail blocking arm. The blocking arm unblocks the No. 8 inversion bar and blocks the No. 8 code bar to invert bit 8, as previously explained.

When both the control and shift keys are depressed simultaneously to generate the null character or one of the S3 through S7 information separator characters, bit 8 must not be inverted if the even parity is to be maintained. When the shift and control keys are both depressed, the control lock bar and the shift lock bar both move to the left by the same amount. The shift lock bar roller therefore remains on the low part of the curved camming surface on the control lock bar and the lower bail blocking arm is not rotated upward. Therefore, bit 8 is not inverted. However, bit 7 is deleted by the control code lever and bit 5 is inverted by the upper bail blocking arm and the shift code lever, as previously explained.

Since the Model 35 transmits an 11-unit code, the cams on the transmitting cam sleeve assembly necessarily have rather short lobes, as compared to those on 5-level, 7.42-unit cam sleeves. The necessary tolerances, which must be allowed in machining these cams and other parts associated with the signal generator, result in a greater percentage of distortion in the generated signals than is normally present in 7.42-unit signal generators. The Model 35 is factory adjusted for a maximum of plus or minus 8% distortion. Wear which occurs in normal operation prior to the scheduled overhaul period can increase this distortion to plus or minus 12 percent. This is also true of single contact distributor-transmitters. In systems where this amount of distortion cannot be tolerated, a signal regenerator is available as an optional accessory. This

regenerator is a silicon controlled rectifier which mounts in the electrical service unit. A contact assembly in the keyboard (or distributor-transmitter) is used to provide accurate timing pulses for the regenerator. This contact opens momentarily during the middle portion of each pulse transmitted from the signal generator. The regenerated signals contain a maximum of plus or minus 5 percent distortion.

Model 35 Typing Unit

The Model 35 type box, illustrated in Figure 13, consists of 16 vertical rows of graphic characters, with four characters in each row. The type box is divided into two fields, as shown. The left, or "figures", field contains the graphics in the 3rd and 4th columns of the ASCII code table (Table I in Part 1). In both of
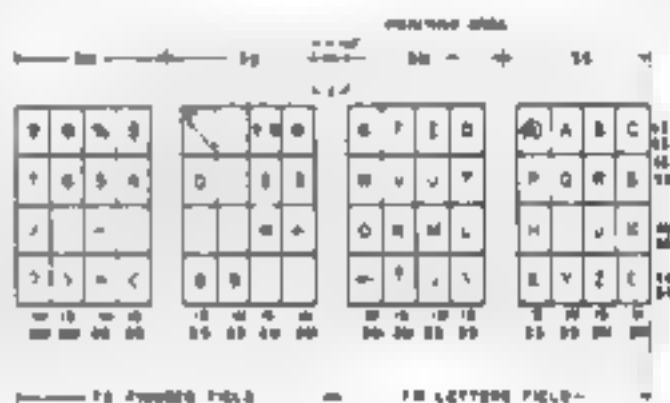

Figure 13. Model 35 Typebox Layout

these columns, bit 7 is a zero, or spacing pulse. The right, or "letters", field contains all of the characters in the 5th and 6th columns of the ASCII table. In both of these columns, bit 7 is a one, or marking pulse. The 7th pulse is therefore used to determine in which direction the type box will move from its home position. It should be noted, however, that use of the terms "letters" and "figures" in reference to ASCII-code equipment is sometimes confusing to telegraph engineers. There are, of course, no letters-shift or figures-shift characters in ASCII. Six of the characters in the so-called "letters" field are not letters, but symbols. Use of the terms "letters" and "figures" is simply a convenient way of identifying the two type box "fields".

The third pulse determines which half of the selected field will be moved to the printing position. If the 3rd pulse is marking, the left half will be so positioned and if the 3rd pulse is spacing, the right half of the type box will move toward the printing position. Pulses 1 and 2 determine which vertical row of characters in the selected half of the field will be positioned below the printing area and pulses 4 and 5 determine which of the 4 characters in the selected vertical row will be moved to the printing area.

The vertical positioning mechanism for the type box used in the Model 35 is basically the same mechanism as that used in the Model 28. However, the horizontal positioning mechanism has been redesigned for use with the new code. Since letters-shift and figures-shift characters are not used in ASCII, the No. 7 code bar is used to perform the equivalent function; that is, to determine which half of the type box will be moved to the printing position. This is the major difference between the 5-level and 8-level horizontal positioning mechanisms.

Model 35 Stunt Box

The Model 35 stunt box is almost identical to the Model 28 stunt box and most of the parts used in the two stunt boxes are interchangeable, including the universal function bar, which can be coded for any character in either the ASCII or the Baudot code. The physical size of the code bar assembly used in the Model 28 prevented inclusion of a No. 8 code bar when the typing unit was modified for use with the ASCII code. The Model 35 stunt box cannot detect the 8th pulse and therefore cannot detect a parity failure, even on functions. Also, there is no "zero" (automatic carriage return-line feed) code bar, and the typing unit cannot be placed in the select or non-select modes, by means of stunt box shift mechanisms, as the Model 28 can. However, there is a print suppression bar in the Model 35 and the typing unit can be placed in the print or non-print mode. A comparison of the functions performed by the code bars in the Models 28 and 35 is shown in Figure 14.

If the Nos. 6 and 7 code bars are both moved to the spacing position, a blocking arm is rotated into a position to block the type box clutch trip arm so that the type box clutch cannot be engaged. Printing is therefore suppressed when any character in the first two columns of the ASCII code table is received. Also, when the Nos. 3, 4, 5, 6, and 7 code bars are all in their marking positions, a similar mechanism blocks the type box clutch trip arm. This suppresses printing when one of the last four characters in the last column of the ASCII code table is received.

Model 35 Tape Punches and Readers

All the Model 35 tape punches perforate chad (fully perforated) tape, one inch wide, with in-line feed holes. All of the punches available for the Model 35 ASR set are equipped with start-stop selector units. At present, there is no punch available which is mechanically linked to the keyboard code bars so that tape can be punched "blind" at a speed greater than 100 words per minute, as on the Model 28. However, either typing or non-typing reperforators are available.

The single-shaft and dual-shaft transmitter-distributors are basically the same design as their 5-level code equivalents, and they are equipped with the same controls, such as tight-tape and tape-out contacts for automatically stopping the transmitter when a tight-tape or tape-out condition occurs. A manual control lever with start, stop, and free-wheeling positions is also used on each transmitter-distributor.

MODEL 28	CODE BARS	MODEL 35
SUPPRESSION		SUPPRESSION
No. 4		No 2
No. 1		No 5
No. 5		No 1
No 2		No 4
No. 3		No 3
COMMON		COMMON
AUTO CR-LF		No 7
SHIFT		No. 6

Figure 14.

Comparison of Models 28 and 35 Code Bar Arrangements

Other 8-Level Teletype Equipment

Non-typing telegraph equipment, such as transmitter-distributors and non-typing reperforators, are not code sensitive, that is, such equipment, when used in a tape-to-tape system, can transmit or punch perforated tape, regardless of the character assignments given to the various permutations of the holes in the tape. (Code insensitive systems are sometimes referred to as "transparent" systems.) Teletype now manufactures self-contained 8-level non-typing reperforators, 8-level transmitter-distributors, 8 level transmitters and 8-level distributors which can be used for sending and receiving the new ASCII code; however, these units can also be used for sending and receiving any 8-level code.

Conclusion

The Models 33 and 35 teleprinters and ASR sets are the first generation of Teletype's ASCII-code telegraph equipment. Other generations of equipment are sure to follow to meet the increasing need for more and more versatile equipment for use in the rapidly expanding, and overlapping, communications and data processing fields. Future management information systems will undoubtedly require more sophisticated equipment than is presently available. New requirements, not yet foreseen, will have to be met

The ASCII code is being revised to include a lower case alphabet in the unassigned area of the code table. Dual case teleprinters are already being developed for use with this revised code

* * * * *

Part I Model 33 appeared in the January 1965 issue of the
Western Union TECHNICAL REVIEW

Fred W Smith was assigned the responsibility for coordinating the engineering requirements for the 8 level Teletype equipment to be used in the General Services Administration's Advanced Record System

Mr Smith has been in charge of the Mechanical Equipment Group in the Telegraph Equipment Engineering office since 1951

He joined the Applied Engineering Division of Western Union in 1948 after having served four years as a radar maintenance and repair officer in the U S Army Signal Corps His responsibilities include the design and field application of mechanical equipment used in start stop printing telegraphy and in reperforator switching

Mr Smith received a degree of Bachelor of Science in Electrical Engineering from the Georgia Institute of Technology in 1938 He is a member of the Institute of Electrical and Electronics Engineers and past Chairman of both the American Institute of Electrical Engineers Committee on Telegraph Systems and the Committee on Standardization of Perforated Tape

Patents Recently Issued to Western Union

Nuclear Bomb Explosion Detecting Device

W. D. Buckingham, F. T. Turner, R. H. Snider

3,147,380—September 1, 1964

A device for detecting and reporting the occurrence of a nuclear bomb explosion before the arrival of the destructive shock wave. Natural events such as thunder, lightning, sunlight, are rejected by the device which is responsive only to the following sequence of events peculiar to nuclear bomb blasts: (a) Sensitivity is limited to a thermal energy blast in a limited wavelength range, (b) A first energy peak of short duration and high intensity, (c) A second energy peak of rapid rise time and high intensity. The housing and screening design further enhance the selectivity. Three symetrically positioned photo-voltaic cells surrounded by an attenuating screen and weatherproof glass housing, detect the energy wave. For each cell a remotely operated incandescent lamp-neon lamp combination is positioned to simulate the conditions of a nuclear blast for test purposes. Reporting of the blast is by a frequency shift in a local oscillator from a normal frequency to an alarm frequency for transmissions to a command center.

Character Recognition System and Apparatus

W. D. Buckingham, F. T. Turner, A. E. Hildreth, Jr.

3,170,138—February 16, 1965

A device for reading characters, including function characters, from a tape or page medium and generating the corresponding telegraph codes. Character images are projected onto a photocell matrix where for each character the covered, or shadowed cells connect to an individual resistive network while a selected group of uncovered cells connect to a second resistive network. The cell currents generate voltages in the two networks which are respectively of opposite polarity the summation of which, in a third network, produces a potential which is substantially higher than that occurring in any other character network pair, as a consequence of the more or less random distribution of the covered and uncovered cells which result for any except the desired character. This voltage fires a thyratron which initiates generation of the appropriate code permutation for the character. Means for centering the image on the matrix are included, upper and lower case characters are distinguished and all necessary function characters are generated.

G. H. Ridings, Facsimile Engineer—Facsimile Div.—Plant & Engineering Dept.

Facsimile Imaging Systems

Part III

Photographic Recording Methods

The simplest type of recording mechanism is of course the drum-type machine. Telephoto recorders are almost universally of the drum type although humidified-paper direct recorders are used to monitor telephoto transmissions. A number of electro-optical transducers are available to vary the intensity of the light in response to the received facsimile signals. A constant-intensity light source can be modulated by Kerr cells or by the electro-optical shutter effect in certain crystals. Or, an electromechanical shutter can be used in which a galvanometer arrangement, as shown, in Figure 20, varies the area of an aperture in the path of the light. This is the method employed in the Muirhead telephoto recorders, in which the density linearity can be altered to match the film or for any other reason, by changing the shape of the lower aperture.

An alternative to this method is to use a light source whose intensity can be varied in response to the incoming facsimile signals. One of the simplest of these is the glow-modulator or crater tube, shown in Figure 21. It is a gas-filled, cold cathode diode with a small hole drilled axially into the cathode. The anode is mounted in line with the cathode structure and has a relatively large hole in its center to permit emission of the light generated in the cathode bore. Physically it resembles the concentrated arc lamp used in the flying spot scanner of Figure 9 in Part II, but although the light concentrates within the small hole or crater,

the intensity is not uniform across the diameter of the crater. It is therefore undesirable to image the crater directly upon the film. Instead, a condenser lens

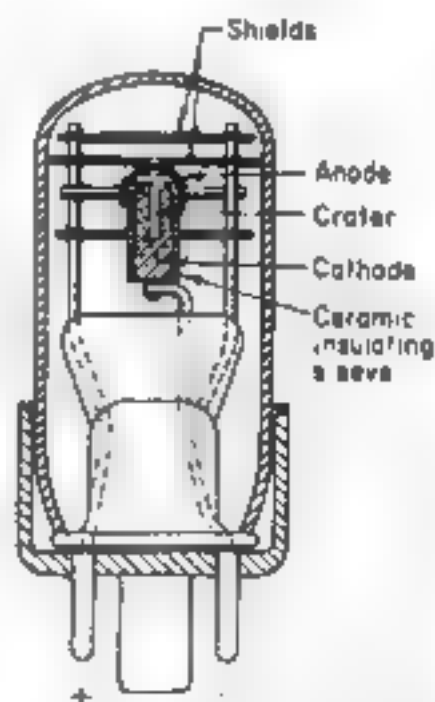Figure 20.   Optics in a Photographic Recorder

Figure 21.   Glow-Modulator Tube

and aperture are generally interposed, as is found in conventional spot projecting lens systems. The tube has a maximum brightness of some 200 candles per square inch and can be modulated at very high speeds. The light output is roughly proportional to the current through the tube and peaks at about 3500 angstroms, making it an excellent source for use with blue-sensitive emulsions. If desired, the amplitude linearity of the circuitry feeding the facsimile signals to the tube may be altered to match the film used or to compensate for any nonlinearity of the tube characteristics. This method of recording is used in photographic recorders of Associated Press Wirephoto and United Press International Telephoto.

Direct Recording Methods—
Dry Recording Media

Drum-type direct recorders utilize dry conductive or capacitive papers. One example of the conductive paper is Western Union's TELEDELTOS*. This paper, illustrated in Figure 22, is a carbon-impregnated-base paper, coated with a thin semi-porous layer of white pigment which gives the composite sheet a light grey appearance. The reverse side of the sheet is sometimes given a coating of metallic lacquer to improve the appearance and make for cleaner handling, but this may be omitted if the surface is highly calendered. The facsimile signals are applied to a stylus, which rides lightly on the surface of the sheet. The coated sheet changes its color to darker shades of grey or black, depending upon the magnitude of the current flowing through the pigment and the conducting sheet to the drum beneath.
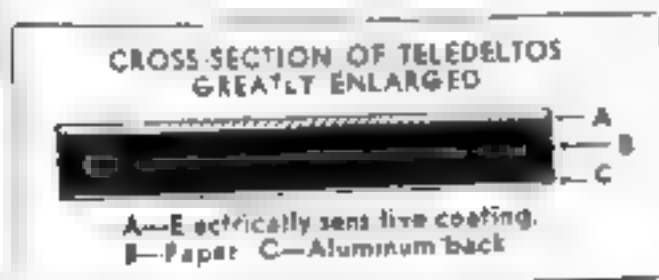
CROSS-SECTION OF TELEDELTOS GREATLY ENLARGED

A—Electrically sensitive coating.
B—Paper   C—Aluminum back

Figure 22   Cross Section of TELEDELTOS Paper

* Registered W.U. Trademark

Capacitive-type papers are made by coating a nonconducting base paper first with a layer of conductive carbon, then with the thin semi-porous layer of pigment. In this case, the current passes through the pigment and along the conductive carbon layer to the edge of the sheet, where it again passes through the pigment to a contact on the front surface of the sheet. If high-frequency marking currents are used, the current will pass directly through the sheet, because the conductive carbon layer and the drum act as the two plates of a capacitor. With either type of paper no further processing of any kind is required and the copy is permanent and unchanged with time. There is little difference in the resolution capability, contrast range or linearity of these two types of dry papers.

Continuous recorders, accommodating rolls of these dry papers up to 350- or 400 ft. long, are used in many applications, and have the advantage of being able to operate unattended for long periods of time. In these recorders, an endless belt mounted on two pulleys supports three or more styli each spaced a scanning line length apart, as shown in Figure 23. Recording paper from the supply roll is fed at the line-feed rate past the path of the styli as the belt carries them in a straight path between the two pulleys. Each stylus, in turn, records one scanning line starting at the lefthand edge of the paper as the preceding stylus leaves the righthand edge and starts its return path. The paper is of course spaced away from the styli on the return path. In one design the styli are mounted solidly to holders on the belt and the stiffness of the paper itself provides the light stylus-to-paper pressure required. In another design, the paper is solidly supported with a metal platen behind it and the styli are flexibly mounted plunger-fashion, with light springs supplying the pressure. A suitable hardened metal skid in each case gradually eases the stylus onto the lefthand edge of the paper. Great precision is necessary in positioning the styli along the scanning line so that a repetitive pattern does not appear in vertical lines, and

PAPER ROLL   PAPER WEB   TEAR OFF EDGE   STYLUS

DRIVEN PULLEY

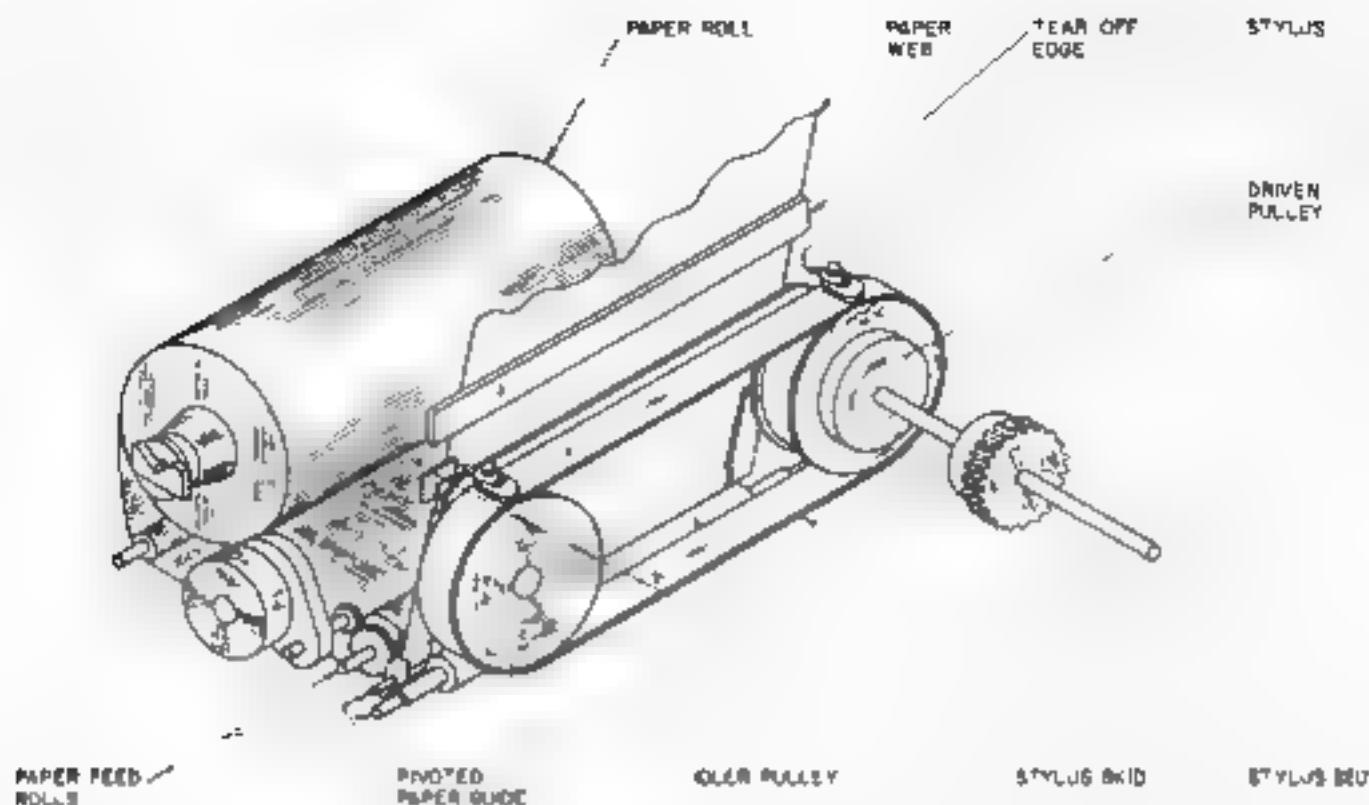PAPER FEED ROLLS   PIVOTED PAPER GUIDE   OLER PULLEY   STYLUS SKID   STYLUS BELT

Figure 23. Continuous Recorder using Dry Paper

also in positioning them perpendicular to the scanning line so that a scanning-line grouping pattern does not appear Here again, some slight degradation in quality as compared with a single-stylus drum-type recorder) is the price we must pay for the convenience these equipments afford Some of these recorders are equipped with a take-up reel for accumulating the recorded copy, others have means for cutting each message from the roll as it is recorded and depositing it into a collector.

Humidified Recording Media

Humidified papers are made by saturating a special long-fibre paper having suitable wet-strength characteristics with an electrolyte under controlled humidity conditions. It is then packed in a sealed container so that it cannot dry out until it is to be used. This paper is used in continuous recorders in which the paper is drawn by feed rollers from a container (which inhibits the paper from drying out) and over an insulating cylinder upon which a metallic spiral is mounted as shown in Figure 24. This spiral lightly sweeps across the back of the paper web

as the cylinder rotates. Across the front of the paper a light metal bail is supported by springs to press lightly against the front of the paper web. A direct current, whose amplitude is controlled by the facsimile signals, passes from the bail through the damp paper to the metallic helix at the point of intersection depositing, by electrolytic action, minute amounts of the material of which the bail is composed. The helix is a single turn helix and as its intersection with the bar
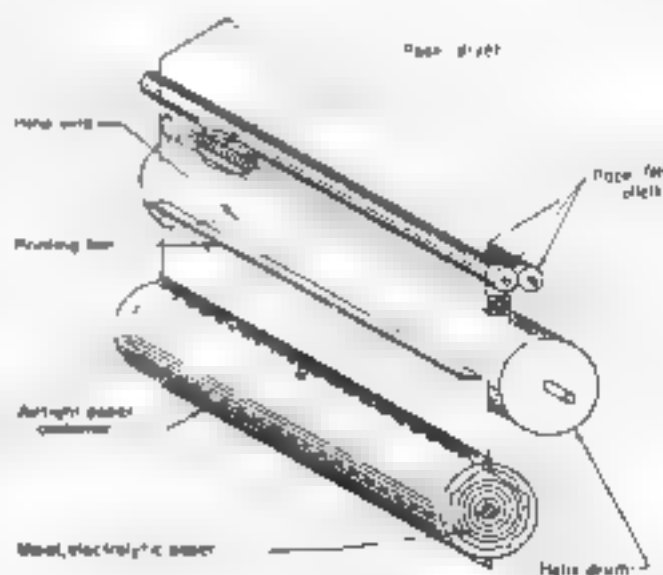

Figure 24. Continuous Recording using Humidified Paper

passes beyond the right edge of the paper web, it starts again at the left edge. Meanwhile the paper has advanced one scanning line width and the facsimile image is formed. In some types of humidified papers the image is not fully developed at this point and the paper is drawn across a heater bar which dries out the paper at the same time completing the development of the image. These papers have a whiter background than the dry papers and therefore some of them have a longer tone scale. About 12 or 13 steps of a 15-step tone scale can be reproduced on some as compared with 9 or 10 steps for the dry papers.

Recorders of this type therefore do a better job of picture reproduction than those using the dry papers and, in fact, are used extensively to monitor transmissions of the news services. In some cases, usually when the picture is received too near the paper's deadline to permit getting a photographic print from the nearest news service office, pictures recorded on the monitor recorder are reproduced in the newspaper. Humidified papers do not have the dimensional stability of dry papers and tend to stretch, shrink, and wrinkle depending upon the adjustment of the machine. Some of these papers darken with age and discolor other papers placed in contact with them. The recording tends to "bleed" or spread and the definition on typescript is therefore slightly poorer than that on dry papers under comparable conditions. Because the humidified papers are translucent, duplicate copies can be made readily on almost any kind of office copier—whereas copies of opaque dry-paper recordings can only be made on certain types of copiers.

Other Recording Media

Since both types of recording have several deficiencies, considerable development has been done on other methods, such as controlled sprays of ink droplets onto plain paper, electromechanical arrangements which transfer small droplets of ink from a wire or thin wheel onto plain paper, and methods which transfer carbon from a sheet of carbon paper onto a sheet of plain paper. Unfortunately, these also have serious deficiencies and have had limited application.

Dr. Ing. Rudolf Hell of Keil has developed a series of recorders using the electromagnetic ink transfer process and Westrex in the United States has recently developed a continuous carbon-paper recorder which has three tiny electromagnetic units mounted on a continuous belt.

Electronic Scanning

Perhaps the most significant improvements in facsimile scanning and recording techniques are some which by their very nature, are economical only in high-volume and therefore highspeed applications. With the possible exception of the multifaced mirror shown in Figures 12 and 13, in Part II, all the scanner and recorder arrangements described so far are limited to low-speed or intermediate-speed applications, i.e., 180 to perhaps 3600 scans per minute. For higher speeds than this electronic scanners and entirely different recording techniques become more economical and more practical. Two general methods are available for scanning the subject copy. First, a flying-spot cathode-ray tube can be employed in which an image of the bright spot on the face of the tube is focused by means of an objective lens upon the subject copy and the light reflected from the subject copy is picked up by a phototube or phototubes. The copy is advanced at the line-feed rate, by feed rollers and the spot swept across the face of the tube by suitable currents in the deflection yoke. The image of this spot sweeps the copy from left to right at a uniform rate and then returns to the left side at a much faster rate. The return sweep is of course "blanked," that is, no signal is transmitted during this interval. The scanning action is similar to that of the mechanical flying-spot and a high-quality photographic lens is required.

The second arrangement utilizes an image orthicon or vidicon television camera tube. In this arrangement a high-quality photographic lens focuses an image of the subject copy upon the mosaic surface of the photocathode and the electron beam of the camera tube sweeps

the photocathode in raster fashion, starting in the upper left-hand corner of the image and moving across to the right-hand edge. Then the beam executes a fast retrace to the left edge but at the same time moves down one scanning line width, so that the second sweep is slightly below the first, and continues this process until the lower right-hand corner is reached at which time the vertical-sweep circuits return the beam to the top of the image. This electron beam picks up the minute charges from each area of the mosaic of the photocathode. These charges are proportional to the intensity of the light striking that area and this stream of signals is transmitted to the distant recorder. In this case, both the horizontal retraces and the vertical retrace are blanked. This arrangement is comparable to the mechanical image dissector, the electron beam taking the place of the image-dissecting aperture.

Electronic Recording

Recorders for high speed applications commonly utilize a flying spot cathode-ray tube with the beam current modulated in accordance with the received facsimile signals. This scanning line of light, of varying intensity, is focused upon the record sheet which is advanced by feed rollers at the line-feed rate. One system records on 35 mm. film but most use electrostatic recording techniques. One system, shown in Figure 25, developed by Xerox employs a selenium-coated drum which is electrostatically charged, then exposed as it rotates at the line-feed rate past the image of the scanning line on the face of the flying spot tube. Light falling on the selenium surface discharges the exposed areas in proportion to the intensity of the light in each area leaving a latent electrostatic image. A black thermo-setting powder is then cascaded or blown across the surface of the drum where it adheres to the charged areas, thereby developing the latent image. Through another charging process the image is caused to transfer to ordinary paper upon which it is fixed by the application of heat. The recorder is designed so that the process is a continuous one,

one portion of the drum being cleaned of any vestige of the previously developed image while another portion is being charged, another exposed, another developed by contact with the powder while the developed image on another section is being transferred to the paper roll. Such a recorder is much too complex and costly for most low-speed applications and by its nature is not suited for intermittent operation. It is more like a newspaper press and can turn out large quantities of copy at low cost if there is a continuous input.

Another technique employed is to use a photosensitive paper such as RCA's ELECTROFAX, which is in effect, a low-cost expendable xerographic plate. With this paper the latent image is formed optically in much the same manner as used in the previous method. After dusting with the thermoplastic-ink powder it is fixed directly on the ELECTRO-FAX paper thereby eliminating the need for the transfer process. This simplifies the recorder mechanism somewhat but the paper cost is substantially higher and the paper is not as fast as the selenium-coated drum. To increase the speed capability, two arrangements have been used to get more light on the paper surface. One employs a "thin-window" cathode-ray tube developed by RCA. With this tube the flying spot of light generated by the electron beam impinging on the phos-
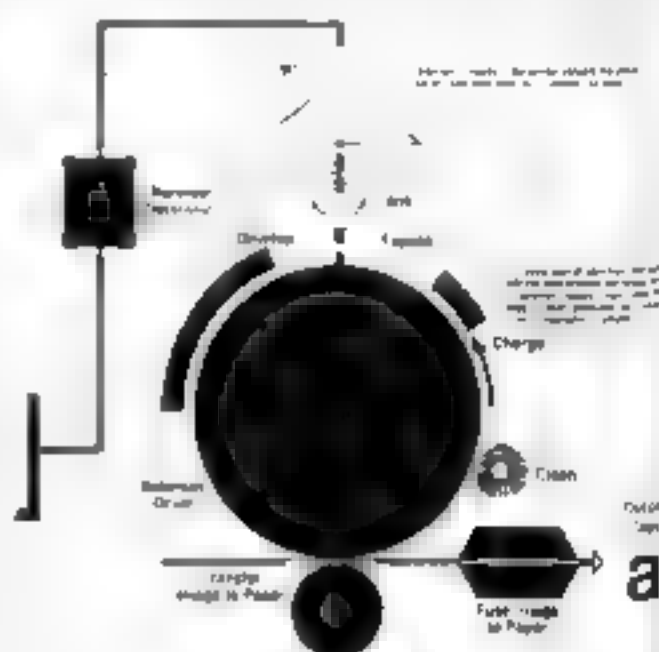
phor on the inside surface of the tube face passes directly through this thin window and strikes the ELECTROFAX paper which is drawn across the face of the tube. This cannot be done with conventional cathode-ray tubes because the thick glass faceplate would ruin the resolution. By thus eliminating the objective lens ordinarily required between the flying-spot tube face and the ELECTROFAX paper, the amount of light on the paper is greatly increased—as much as 100 times.

Another arrangement employs a cathode-ray tube which has a strip of coherent glass fibres imbedded in its face. These tiny light pipes conduct the light from the phosphor straight through the faceplate of the tube to the ELECTRO-FAX paper drawn across the face without the dispersion and loss of resolution which would occur with a conventional faceplate. Glass fibres, as small as 0.002 or 0.003 inch, are used giving fairly good resolution. Machines employing ELEC-TROFAX paper are fairly complicated and costly and the process is essentially a sequential one requiring a large and fairly continuous input for economical operation.

Another electrostatic process employed in several recorders utilizes a poly-coated paper. Latent images are formed on this paper by the application of voltages to a series of conducting points spaced close to the surface of the sheet. Electrostatic charges are built up on the coated surface which attract a powdered ink thereby developing the image. Application of heat softens the polystyrene coating thereby fixing the image. A. B. Dick Company developed several facsimile recorders employing cathode-ray tubes which have a strip of fine coherent wires imbedded in the faceplate of the tubes so that the electron beam can be used to apply varying voltages to these wires as it sweeps across the tube face. These wires conduct the voltages to the front of the faceplate where charges are applied to the poly-coated paper surface which is drawn across the tube face. The wires insulated from each other are spaced quite close together—about 280 to the inch—so that fairly good resolution is possible. A typical recorder configuration is shown in Figure 26.
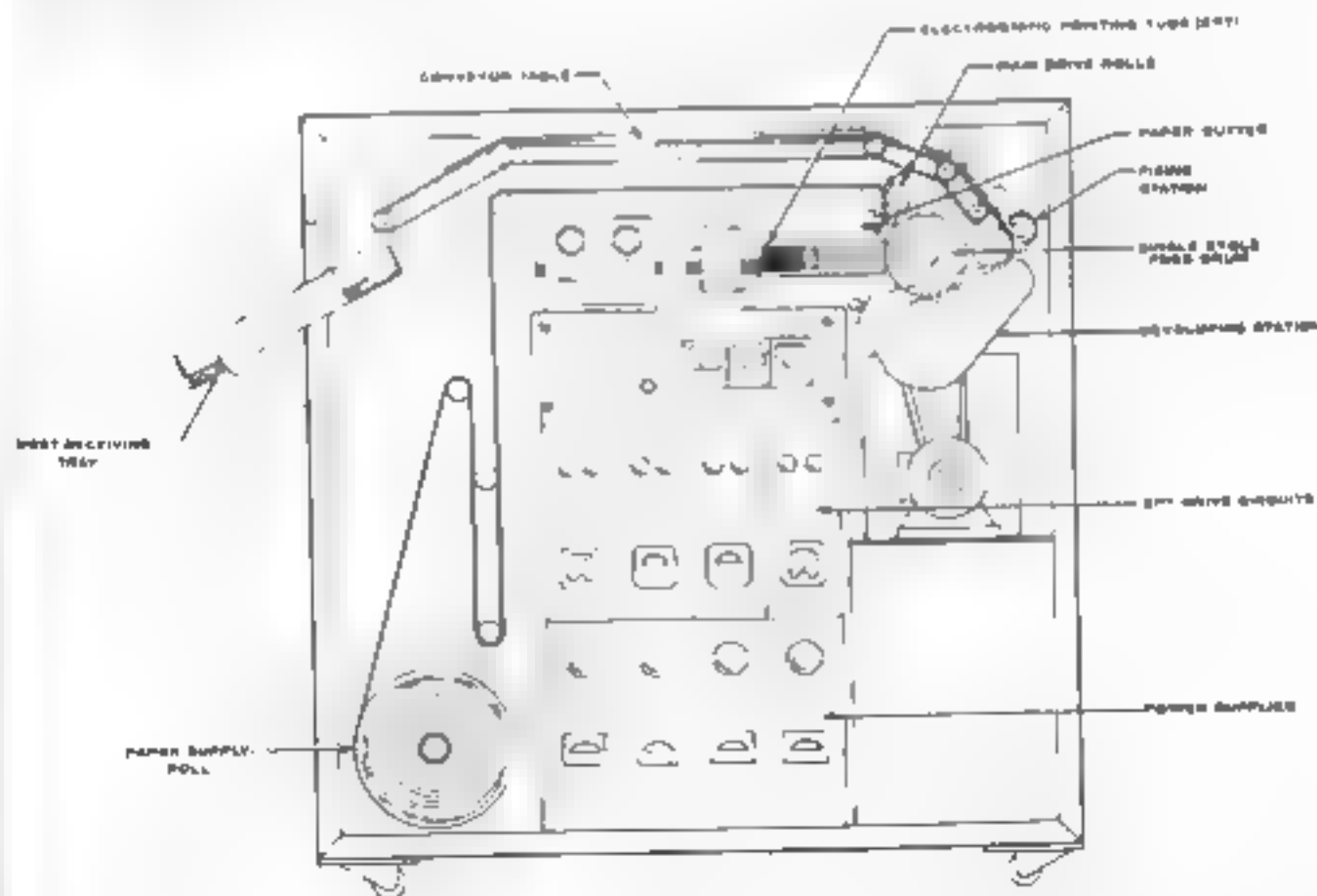

Figure 26. Electrostatic Recorder using Coated Paper

All of these electrostatic recording methods are capable of high contrast and easy reproduction of duplicate copies. They give good reproduction of typescript but have a very limited tone scale and therefore do not give good picture reproduction. They require only small amounts of recording power. Horizontal linearity of electronic systems is generally inferior to that of mechanical systems but since the same type of tube and deflection yoke is often used in both the scanner and recorder nonlinearities originating therein can cancel out. Other nonlinearities are minimized by exercising great care in the design of the sweep circuits, stabilization of voltages, etc. Because of the high cost of the wide-band channels required for high-speed systems, very few requiring channels wider than a voice band (nominal 3 kc.) have actually been placed in service. However nation-wide microwave systems have reduced and will probably continue to reduce the channel cost so that in the future more and more high-speed facsimile system applications are likely.

Heretofore, most facsimile systems for private commercial applications have been set up on a point-to-point leased arrangement in which the patron pays a monthly rental for the equipment (with maintenance) and for circuits which are permanently connected. Arrangements are now being made to provide facsimile service on a "dial-up" push-button basis in which the patron pays a monthly rental charge for the equipment (with maintenance) and a toll charge for each circuit connection made. Such service will be available (through the Bell System by use of a data set) and through Western Union's new Broadband Exchange Service, which is scheduled to start operation this year.* This latter system will eventually provide, by push-button selection, nominal 2 kc., 8 kc., 16 kc. and 48 kc. channels as well as the nominal 4 kc. voice channel.

A transistorized transceiver has been designed for use over the 4 kc. channels and it is expected that higher speed equip-

* Note: This paper was presented to the S.P.C.E. on Feb. 1, 1964, several months prior to the inauguration of the Broadband Exchange Service on Sept. 30, 1964.

ment for use over the 16 kc. channels will be available at a later date.

Fibre Optics

The recent development of fibre optics has stirred the imagination of facsimile equipment designers and theoretically at least opened new design approaches. Not only do these light pipes make possible the conduction of light from one place to another without serious dispersion or scattering, as for example through the faceplate of the cathode-ray tube previously mentioned, but they make possible amplified scanning arrangements. For example, in a suggested scanner configuration, illustrated in Figure 27, instead of projecting a floodlighted strip of the subject copy optically upon an image-dissecting helix and slit or spiral and slit a single row of these fibres can be placed close to the floodlighted strip of copy and in sequential fashion the opposite ends of the fibres can be formed into a circle. Then a single fibre (about the size of the elemental area we wish to explore) may be mounted on a disc so that one end scans the circle of fibre ends and the other conducts the light thus picked up, to a phototube at the center of the disc, thereby making a simple image-dissector type of flat-bed scanner.

The advantages of such an arrangement are: (1) higher light levels and (2) a more compact design since we do not have to project optically an image of the strip of copy upon the moving aperture. Unfortunately, in the present state of the art there are many deficiencies in such arrangements. Aside from the obvious problem of broken fibres, variations in the diameter of the fibres, deviations from absolute flatness in grinding and polishing of the fibre ends either at the line end or circle end, any chipping of these fibre ends in the grinding and polishing or in handling or the accumulation of dirt or paper fibres on the ends of the glass fibres all cause a variation in the light level along the scanning line. This light variation is a purely random variation and cannot readily be compensated for, so that vertical streaks appear in the copy. Then there is the problem of getting the line of
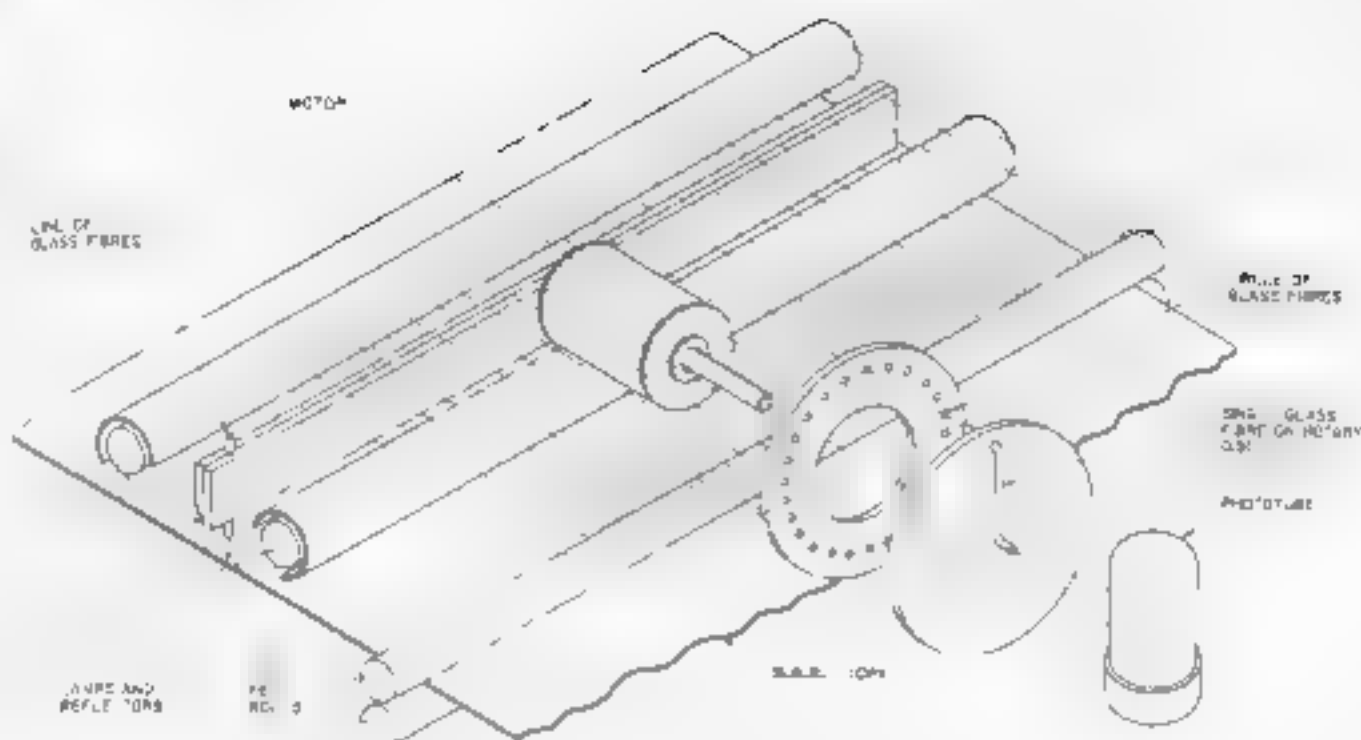
Figure 27   Fiber Optics Flat-Bed Scanner Configuration

fibres close enough to the copy to prevent loss of resolution due to overlapping of the cones of light acceptance of adjacent fibres without projecting into the path of the light employed to illuminate the copy.

Perhaps some day these problems will be satisfactorily resolved, meanwhile we shall continue to employ photographic lenses and moving apertures.

Acknowledgments

Mr. G. H. Ridings is Facsimile Engineer in the Plant & Engineering Department He has made a number of contributions to the advancement of the art of record communications, the most notable of which is the Desk Fax

In 1960 he won the F. E. d'Humy Award for his significant achievements in the technology of facsimile transmission and his contribution to the telegraph art He is a fellow of IREE and a member of the EIA facsimile committee. Mr Ridings achievements are further noted on page 70 of this issue

O. W. Swenson, Engineering Associate,-Telegraph Equipment Div.—P & E Dept.

Ribbon Reinker

for the

New 900 C.P.M. Tickers

A new ribbon reinker has been developed for the new high-speed 900 cpm stock quotation ticker, which was introduced into Western Union's Private Wire Service in June 1964.[1] The new reinker functions as part of the ticker's printing and ribbon reversing mechanism, to lengthen the life of the ribbon.

Prior to the installation of the new tickers in this service, a group of units was tested. It was found that the life expectancy of the ink ribbon in the ticker was very short, as compared to lower speed teleprinters (only 3 or 4 days based on an "average" trading day on the Stock Exchange) This was primarily due to the ticker design, that is, the narrow width of the type pallet used, the limited area of the ribbon used in printing, and (on tickers used in projectors) the need for dense copy required on the projector tape to get good copy on the projector screen.

The short ribbon life would obviously mean extremely high ribbon and maintenance costs because of the frequency of replacement, particularly in projector units where the ribbon is not readily accessible. This also indicated that frequent interruptions to service would be necessary to change ribbons. Obviously a ribbon reinker, or rejuvenator, was an economic and practical necessity

Design Objectives

Commercial reinkers were investigated, but none of them could be readily adapted to fit within the rather limited space available in the 900 cpm ticker. Therefore, it was found necessary to develop an entirely new reinking device based on the following design objectives:

Ink Cartridge

1. The ink cartridge must be easy to install and readily replaceable, preferably by the customer.
2. It must be made of a plastic material and so designed as to be easily molded at low cost
3. The cartridge must be equipped with a wick arrangement designed to provide a uniform flow of ink to the ribbon
4. A vent hole obviously must be provided, but a means of sealing the ink cartridge for shipping and storage purposes must also be provided.
5. The design of the cartridge must be such that it will not interfere with any of the ticker mechanism.

Reinker Mechanism

1. It must be possible to install the reinker mechanism without machining, or otherwise disturbing, the present ticker mechanism, if possible.
2. A camming function must be provided for the cartridge, to work in conjunction with the shift mechanism of the ticker, so that reinking of the ribbon will occur as the ribbon is moved in one direction only. This will avoid over-inking and prolong the life of the ink supply.
3. The ribbon shall be reinked in line with the area where the printing occurs to provide maximum density of copy with a minimum flow of ink
4. The reinker shall be kept within the limits of the ticker cover and shall not cause interference with any of the ticker functions.
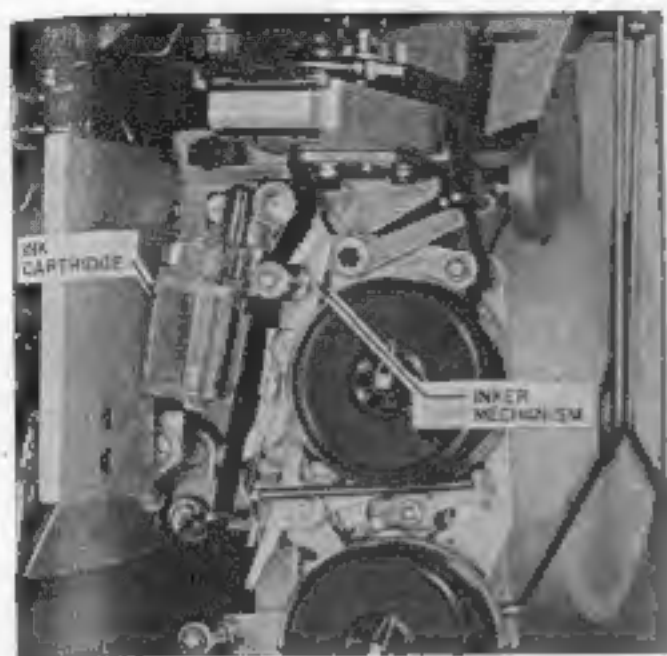
Figure 1. Reinker Mechanism and Ink Cartridge mounted in Ticker

Figure 1 shows the reinker mechanism and ink cartridge mounted in the ticker. Figure 2 is a detailed drawing of the reinker and the associated ribbon mechanism of the ticker. Figure 3 shows the ink cartridge.

Installation

To install the reinker mechanism, the link between the upper and lower ribbon reversing levers is removed and the reinker mounting link installed in its place. It is fastened to the two reversing levers by means of the "E" rings normally used to secure the discarded link. The ribbon is then installed in the ticker in the normal manner, except that it is threaded around the inking roller, as shown in Figure 2. The ink cartridge vent tube is then broken off to permit air to enter the ink chamber and the wick seal is removed. The ink cartridge is installed by sliding it into the position shown in Figure 2, until the clamp spring snaps into place to hold the cartridge wick in correct alignment with the inking roller. The cylindrical projection on the bottom of the cartridge, shown in Figure 2, fits into an elongated slot in the bracket clamp and serves as a guide pin to insure proper alignment between the cartridge and the roller. Note that the only modification necessary to the existing ticker mechanism is the removal of the connecting link between the ribbon reverse levers.
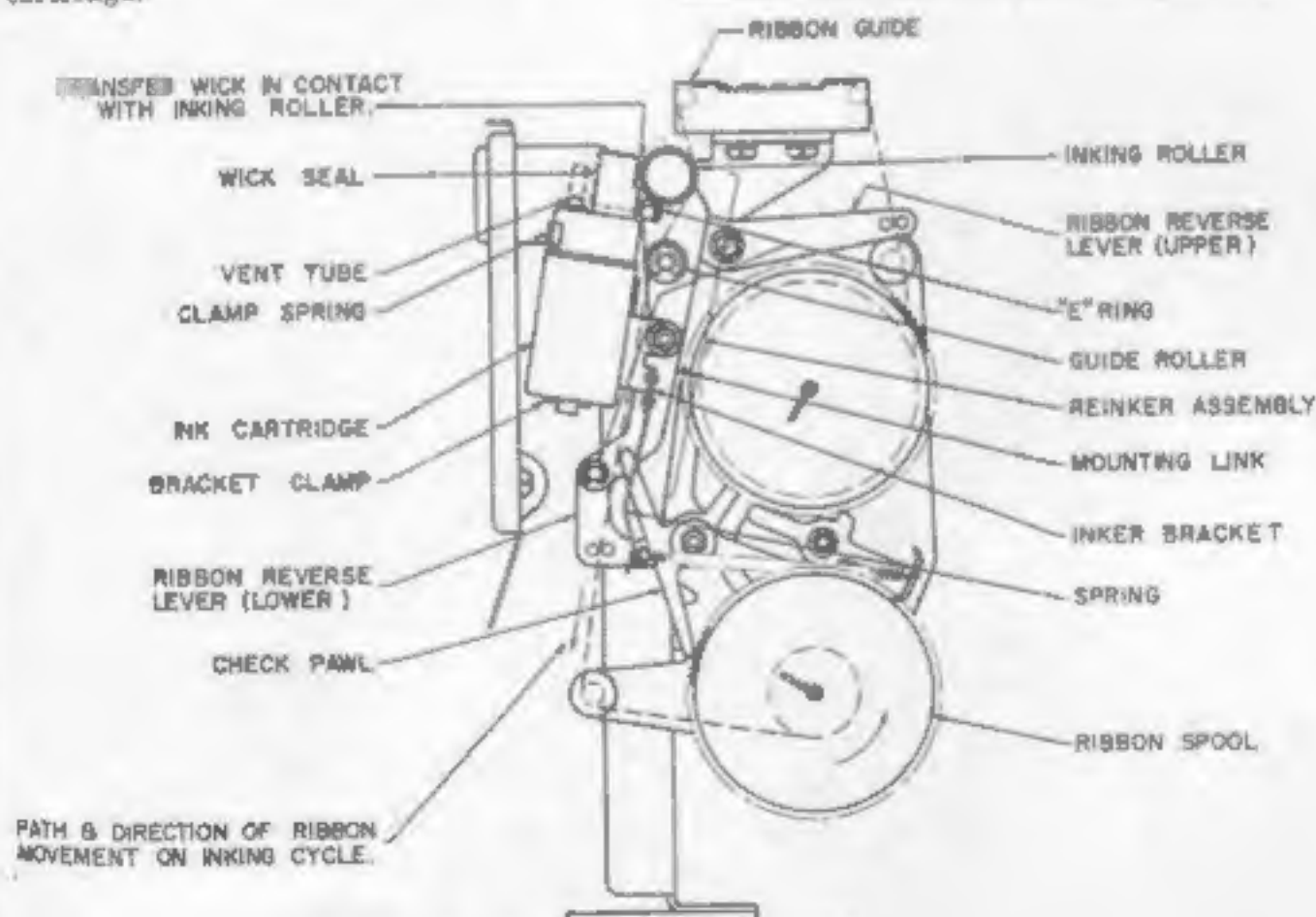

Figure 2. Detailed Drawing of Reinker

Operation

The reinker moves into its inking cycle when the upper ribbon reverse lever is tripped by the ribbon reversing eyelet. The reinker then moves upward until the transfer wick of the ink cartridge comes in contact with the inking roller. The ink then flows from the main wick through the transfer wick and thence to the inking roller, which then applies it to the ribbon. The leaf spring, which is in contact with the check pawl of the ticker ribbon feed mechanism, holds the cartridge in this position until the reinker goes into its non-inking cycle. This occurs when the lower ribbon reverse lever is tripped by the reversing eyelet at the opposite end of the ribbon. The reinker then moves downward and the transfer wick becomes disengaged from the inking roller. Thus, the ink previously applied to the ribbon has time to spread evenly in the ribbon before the next inking cycle occurs.

A silk ribbon is used with the reinker to increase the ribbon life and produce better copy on projector units.

Advantages

The ribbon life has been increased ten times, from 3 or 4 average trading days to approximately 40 days. The ink cartridge lasts approximately 20 days. Replacement of the ink cartridge is simple and can easily be done by the customer. The need to change ribbons less frequently results in a considerable saving in maintenance labor.

The total cost of ink cartridges and silk ribbons is only about 1/3 of the cost of the cotton ribbons used without a reinker.
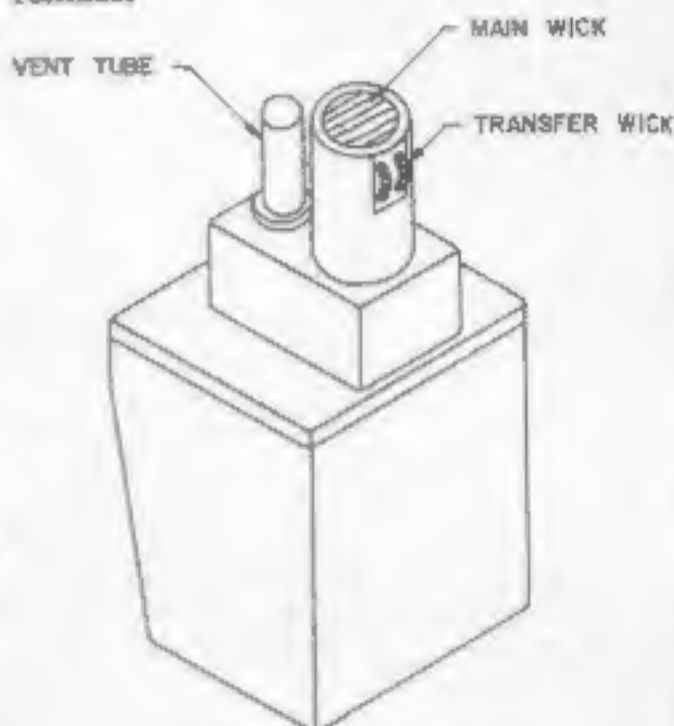

Figure 1. Ink Cartridge

Acknowledgments

The author wishes to acknowledge the guidance of Mr. F. W. Smith in the preparation of this article and the cooperation of Messrs. C. Turner and G. A. Straub in supplying equipment and supplies for testing the reinker. He also wishes to acknowledge the cooperation of Mr. B. L. Kline in selecting the special inks and ribbons used in the reinker.

* * * *

Reference

1. C. Turner and G. A. Straub—Expanded Private Wire Service for the New York Stock Exchange, Western Union TECHNICAL REVIEW, Vol. 18, No. 3, (July 1964).

Mr. O. W. Swenson, an engineering associate in the Telegraph Equipment Division, joined Western Union in 1921. He has served in various capacities in the Plant and Engineering Department. Since 1954 he has been assigned to the Mechanical Equipment Group. In this assignment, Mr. Swenson has participated in the design of many different kinds of telegraph equipment, including the loop-gate transmitter, message separator teleprinters, and the data card transmitter. On the latter project, he redesigned the original data card reader in order to improve the mechanical operation and reliability of the unit. He also designed the stylus assembly which is now being used very successfully on the above reader.

In addition, he has been primarily responsible for the design of many other types of apparatus, including the tape crimpers used in the Plans 55 and 57 reperforator switching centers, and the ribbon reinker described in this article.

Book Review

Introduction to Integrated Semiconductor Circuits by Adi J. Khambata, J. Wiley, New York 1963 (233 pp.)

The author, a senior development engineer with extensive experience in the field, has written an introductory report on the fascinating subject of micro-electronics otherwise known as Integrated Circuits. As such it adheres to the fundamental five "W"s: what, when, where, who, why and even includes a projection into the future. The bibliography at the end of the book is extensive but, considering the dynamic developments in this field, far from complete.

The book is organized into five sections, ostensibly for non-sequential study by users with different backgrounds.

The first section, dwells on the historical development and then jumps to systems considerations and applications which, to this reviewer, do not seem related enough.

The second section describes the techniques and chemical processes necessary to produce these circuits, starting from basic semiconductor technology, through thin-film processes and concluding with the fabrication of integrated circuits themselves.

The third section describes the separate elements in integrated circuits, from diodes and their parasitics through capacitors, resistors, transistors and common anode or cathode arrays. Design problems, arising out of their particular properties, are discussed. Such evaluations are important to the discrete elements circuit designer who has to find out to what extent his brain child can be custom integrated. While many standard logic and other circuits are amenable to integrated circuits forms, and are in fact available off-the-shelf, some are not. Hence, the discrete form circuit may require modification before it can be integrated to achieve ultimately the identical electrical function. One example of these problems is that inductance is not readily realizable and another is that resistor tolerances as close as those available in discrete form usually cannot be obtained. In chapter 9 of this section, the author reviews the subject of semiconductor logic circuits, rather unrelated to the topic of the section and, in fact, to the book itself. The chapter, per se, is very well written but the fact remains that to a logic designer, as distinct from a circuit designer, it makes little difference whether his system is realized through discrete components or integrated circuits.

The fourth section covers important developments of other types of microcircuits designed to overcome some of the inherent limitations of integrated circuits. These types include the hybrid (partially integrated), thin film and multi-chip circuits, their mountings, configurations and justification.

The fifth section covers several topics such as packaging, mechanical considerations, testing, reliability and, of course, maintainability. This last, well organized section of the book concludes with recent advances and future projections and summarizes vital information for incipient users of integrated circuits.

An up-to-date bibliography and detailed index make this book an excellent one for acquainting prospective users with the exciting new subject of Integrated Circuits.

—Jack Eliezer

Western Union Engineers

Elected

Fellows of I.E.E.E.

J. E. Boughtwood   G. H. Ridings

Each year the Institute of Electrical and Electronic Engineers selects from its world-wide membership of some 160,000, a very limited group for elevation to the grade of Fellow, an honorary designation based on a member's exceptional record for research, development, applied engineering, educational or managerial progress in his profession. Of the 125 members awarded this distinction this year—10 were from the Metropolitan New York, Fort Monmouth, New Jersey area.

We are happy to announce that, of these ten, two are members of Western Union's home office Engineering Staff—J. Edwin Boughtwood and Garvice H. Ridings.

Mr. Boughtwood, whose citation for the Fellow award reads "for contributions to frequency division multiplex and FM data and telegraph transmission," is at present Transmission Systems Engineer in the Plant and Engineering Department. In this capacity, he is the Division Head responsible for research, development and engineering in high speed digital transmission systems and test equipment as well as continued activity in carrier systems development for government and commercial use.

Mr. Boughtwood joined Western Union in 1930 directly after earning his engineering degree at Northeastern University. He is the author of a number of technical papers and articles and holds many patents in the field of carrier telegraph and data transmission.

Mr. Ridings, whose citation for the Fellow award reads "for achievements in the technology of facsimile transmission" is at present Facsimile Engineer in the Plant and Engineering Department. He is responsible for the development of Western Union facsimile systems and equipment and provides assistance to other departments in the operation and maintenance of Western Union's public message and private wire facsimile systems.

Mr. Ridings received his engineering degree from Virginia Polytechnic Institute in 1926 and joined Western Union that same year. He is the author of a number of articles on facsimile technology and is named as the inventor or co-inventor in over 50 U.S. patents. He is a member of the Electronic Industries Association TR-29 Facsimile Committee.

Western Union is proud of the achievements of Mr. Boughtwood and Mr. Ridings and of the recognition accorded them by the Institute of Electrical and Electronic Engineers.